ERDC/GSL TR-07-19

Geotechnical and Structures Laboratory

US Army Corps of Engineers®
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Dust Abatement Program

Laboratory Investigation of Chemical Dust Palliative Performance on Sandy Soil

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June 2007

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Final report

Prepared for Headquarters, U.S. Army Corps of Engineers
Washington, DC 20314-1000

and Marine Corps Systems Command
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Abstract: The U.S. Army and Marine Corps initiated a search for chemical dust palliatives for mitigating dust on helipads. The purpose of this investigation was to evaluate the effectiveness of current technologies for suppressing dust caused by rotor wash during helicopter landings. The study used an air impingement device to simulate wind speeds similar to field conditions. Chemical dust suppressants were applied topically to prepared soil specimens and allowed to cure for 1 and 48 hr. Effectiveness was determined from the relative weight loss of the soil samples from erosion during the test procedure. An optical sensor was installed in the test device to provide an additional method for quantifying performance.

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Preface

The purpose of this report is to present results from a laboratory evaluation of chemical dust palliatives for use on helipads. Chemicals selected for use on helipads should be able to resist wind velocities created by rotary-wing aircraft during takeoff and landings. This report provides data for the following:

a. Evaluating laboratory procedures for screening potential dust palliatives.
b. Evaluating relative effectiveness of chemical dust suppressants.
c. Evaluating the effect of application rate on dust palliative performance.
d. Evaluating the effect of cure time on dust palliative performance.

Projected users of this report include units charged with expedient helipad construction and agencies assigned operations planning responsibilities.

The project described in this report is part of the Joint Rapid Airfield Construction program sponsored by Headquarters, U.S. Army Corps of Engineers, Washington, DC, and the Dust Abatement Program currently sponsored by the Marine Corps Systems Command, Quantico, VA.

This publication was prepared by personnel from the U.S. Army Engineer Research and Development Center (ERDC), Geotechnical and Structures Laboratory (GSL), Vicksburg, MS. The findings and recommendations presented in this report are based upon laboratory tests conducted at ERDC from June 2005 to February 2006. Members of the research team were John F. Rushing, Dr. J. Kent Newman, Timothy J. McCaffrey, Jake Falls, and Joe Tom, Jr., all of the Airfield and Pavements Branch (APB), GSL. Rushing, Dr. Newman, and McCaffrey prepared this publication under the supervision of Don R. Alexander, Chief, APB; Dr. Larry N. Lynch, Acting Chief, Engineering Systems and Materials Division; Dr. William P. Grogan, Deputy Director, GSL; and Dr. David W. Pittman, Director, GSL.

COL Richard B. Jenkins was Commander and Executive Director of ERDC. Dr. James R. Houston was Director.

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Unit Conversion Factors

Multiply	By	To Obtain
degrees Fahrenheit	(F-32)/1.8	degrees Celsius
gallons (U.S. liquid)	3.785412 E-03	cubic meters
inches	0.0254	meters
square yards	0.8361274	square meters

Summary

The ERDC conducted a laboratory investigation to predict performance of dust palliatives used to prevent brownout on helipads. Fifteen commercially available dust palliatives were evaluated in this study. Application rates and curing times were varied to identify optimal performance for each palliative. Air impingement tests served as the mechanism for determining relative effectiveness. Erosion potential data were analyzed along with optical dust concentration measurements to provide results.

The following conclusions were derived from laboratory testing at ERDC in FY05 and FY06:

a. The application device fabricated for dispersing dust palliatives provided an excellent method for achieving uniform distribution and desired application rates. This design produced flow rates, velocities, and profiles very similar to field applicators.
b. Placing treated samples under infrared lamps provided an efficient mechanism for accelerating water evaporation and subsequent curing of dust palliatives that was similar to field curing conditions.
c. The air impingement device was proficient at imparting consistent air velocities capable of eroding the surface of treated samples. The percentage of the area on the surface of samples that eroded varied from 0 to 100 percent, depending on the effectiveness and quantity of product.
d. The traffic simulation device caused the surface of some treated samples to crack. However, the statistical variability within the sample sets obscured the data and presented difficulty in determining the effect of the test.
e. Measuring the weight of material dislodged from the sample during the air impingement test provided quantitative data for comparing dust palliative effectiveness. This method of comparison does not differentiate between soil that is eroded and soil that stays suspended in the air as dust. Some products provide little resistance to wind erosion but agglomerate soil particles so that they do not become airborne.
f. The optical sensing device provided quantitative comparisons of the dust palliatives by only measuring particles less than 100 microns. This method of comparison more accurately characterizes product performance, but is limited to certain soil types. High concentrations of detectible particles in

the soil would easily exceed the maximum concentration of 200 mg/m^3 for the sensor.

g. Placing samples under the curing lamps resulted in statistically different performance values for many of the products. The change in performance is attributed to the change in physical properties of the palliatives from water evaporation (when applicable). Slight changes in physical properties of the active constituents of some palliatives may result from thermal differences resulting from the infrared radiation.
h. The air impingement test does not simulate the effect of wheeled vehicles on treated soils.
i. Polymer emulsions used as dust palliatives form a hard, tough crust on the soil surface. The crust thickness is governed by the product quantity applied. Thin crusts (less than 10 mm) are not able to withstand excess forces from wind or vehicles. Any disturbed areas will reveal untreated soil underneath.
j. The emulsified rubber performed similarly to the polymer emulsions. This product had similar properties but formed a more flexible surface crust. The crust was more difficult to disturb but generally thinner for similar quantities of product.
k. The synthetic fluids did not form a hard crust on the surface of treated samples. They provided marginal resistance to erosion in the air impingement test. The performance was not highly dependent on application rate. The fluids had higher penetration depths during the longer curing time. The penetration for these products was greater than any other type of product.
l. The properties of the chloride salts were dependent on the environmental conditions. Samples cured for 1 hr had a soft, wet surface. Samples cured for 48 hr were very brittle from the loss of water through evaporation.
m. The polysaccharide exhibited properties similar to the chloride salts. Curing resulted in a brittle surface crust.
n. The samples treated with glycerol exhibited properties similar to the synthetic fluids. These samples performed more poorly than the synthetic fluids during the air impingement test.
o. The emulsified hydrocarbon performed poorly in all tests. This product was unable to provide resistance to the air impingement test.

1 Introduction

Helicopters operating on unpaved surfaces are continually hindered by dust and debris becoming entrained in their rotor wash. Brownouts induced by dust during helicopter takeoffs or landings are a main cause of accidents. Safety hazards also emerge for ground personnel when dust and debris invade working areas adjacent to landing sites. In addition to safety concerns, maintenance requirements greatly increase when rotary-wing aircraft operate in dusty conditions. Decreases in engine and rotor life increase the cost of operations. Existing technologies for mitigating dust hazards are potentially effective, but the lack of controlled comparisons limits the user's ability to make an informed judgment when selecting materials to meet specific mission objectives. As a result, the ERDC initiated an effort to develop a laboratory protocol for screening potential dust palliatives and predicting performance. Results from this study were compared with field data to determine correlations with observed performance during large-scale testing.

Objective

The objectives of this investigation were to develop a testing method for rapidly screening potential dust palliatives and to use this method to identify products with optimal properties for reducing dust generation during rotary-wing aircraft landings. This report provides data for the following:

a. Evaluating laboratory procedures for screening potential dust palliatives.
b. Evaluating relative effectiveness of chemical dust suppressants.
c. Evaluating the effect of application rate on dust palliative performance.
d. Evaluating the effect of cure time on dust palliative performance.

Scope

This document describes the procedures and results from a laboratory evaluation of dust palliative performance. Fifteen commercially available dust palliatives were used in this study. Results from air impingement testing provided inferences on the potential performance of products on helicopter landing surfaces. Laboratory equipment was fabricated that would allow for rapid testing of small samples with reproducible characteristics. The wind erosion potential of treated soil samples was measured by the weight loss during the air impingement test. Additionally, an optical sensor within the testing chamber measured relative concentrations of the dust emitted from test specimens. Multiple application rates and curing times were used in an attempt to identify optimal conditions for product performance.

2 Characteristics of Chemical Dust Palliatives

Each of the products evaluated in this study is commercially available and marketed as an agent for suppressing dust. Products vary in chemical makeup and the mechanism by which they provide dust abatement. The products are grouped according to their chemical makeup, as described in the following paragraphs.

Polymer emulsions

DC 100®, Envirotac II®, Helotron®, LDC®, Soil~Sement®, and Soiltac® are classified as polymer emulsions. These products are generally vinyl acetate or acrylic-based copolymers suspended in an aqueous phase by surfactants. They typically consist of 40 to 50 percent solid particles by weight of emulsion. Once they are applied, the polymer particles begin to coalesce as the water evaporates from the system, leaving a soil-polymer matrix that prevents small dust particles from escaping the surface. The polymers used for dust control typically have excellent tensile and flexural strengths, adhesion to soil particles, and resistance to water. Helotron® consists of a polymeric material that is chemically different from the other products and forms a more flexible, elastic binder. The polymer emulsions used in this evaluation were diluted with three parts water for each part product prior to application in order to reduce viscosity.

Synthetic fluids

Durasoil®, EK-35®, and Envirokleen® are synthetic organic fluids that are designed to be applied to a soil "as received." These fluids are not miscible with water and therefore are unable to be diluted. They consist of isoalkanes that do not dry or cure with time. The reworkable binder is ready for immediate use upon application and maintains effectiveness over extended periods of time.

Chloride salts

Dust Fyghter®, calcium chloride, and magnesium chloride are all chloride salts. Dust Fyghter® is a commercial product containing calcium, magnesium, and sodium chloride salts. The solution typically contains approximately 38 percent chloride salt by weight. Calcium chloride and magnesium chloride are available from multiple sources. These materials were received as powders and dissolved in water prior to application. Calcium chloride was mixed to a concentration of 38 percent by weight. Magnesium chloride was mixed to a concentration of 32 percent by weight. Chloride salts are deliquescent materials and have been used for many years as a low-cost solution for dust problems. They maintain effectiveness by absorbing moisture from the air and binding soil particles together. Long-term efficiency of chloride salts is sometimes limited because the material is water soluble and will leach from the soil with prolonged exposure to rainfall. Chloride salts are also known to be highly corrosive materials and will increase maintenance requirements for equipment operating on areas onto which they have been sprayed.

Polysaccharide

Surtac® is a polysaccharide-based system composed of sugar, starch, and surfactants suspended in an aqueous solution. It is shipped in a concentrated form that may be diluted depending upon its intended use. Surtac® provides dust abatement by encapsulating soil particles and creating a binding network throughout the treated area. The binder is water soluble and reworkable; however, it is also susceptible to leaching from the soil with heavy rainfall.

Glycerol

Glycerol is a water-miscible fluid that provides dust abatement by encapsulating soil particles and inducing high surface tension at the granular interface. Glycerol is naturally a very viscous fluid and was mixed with water at a concentration of 75 percent glycerol/25 percent water by volume to reduce the viscosity for spraying.

Emulsified hydrocarbon

RDC 600® is a low molecular weight hydrocarbon suspended in water. It provides dust abatement through mechanisms similar to those of the polymer emulsions and emulsified rubber. Unlike the previously mentioned products, RDC 600® does not form a strong bond. It remains soft and exhibits properties of a wax once the water evaporates from the system.

3 Laboratory Test Description

The test method developed for this evaluation was designed to provide a mechanism for rapidly screening multiple chemicals in various application scenarios in order to make inferences about performance. This method was designed specifically for products intended for use on rotary-wing and fixed-wing aircraft landing surfaces. Descriptions of the procedures used for product evaluation are described below.

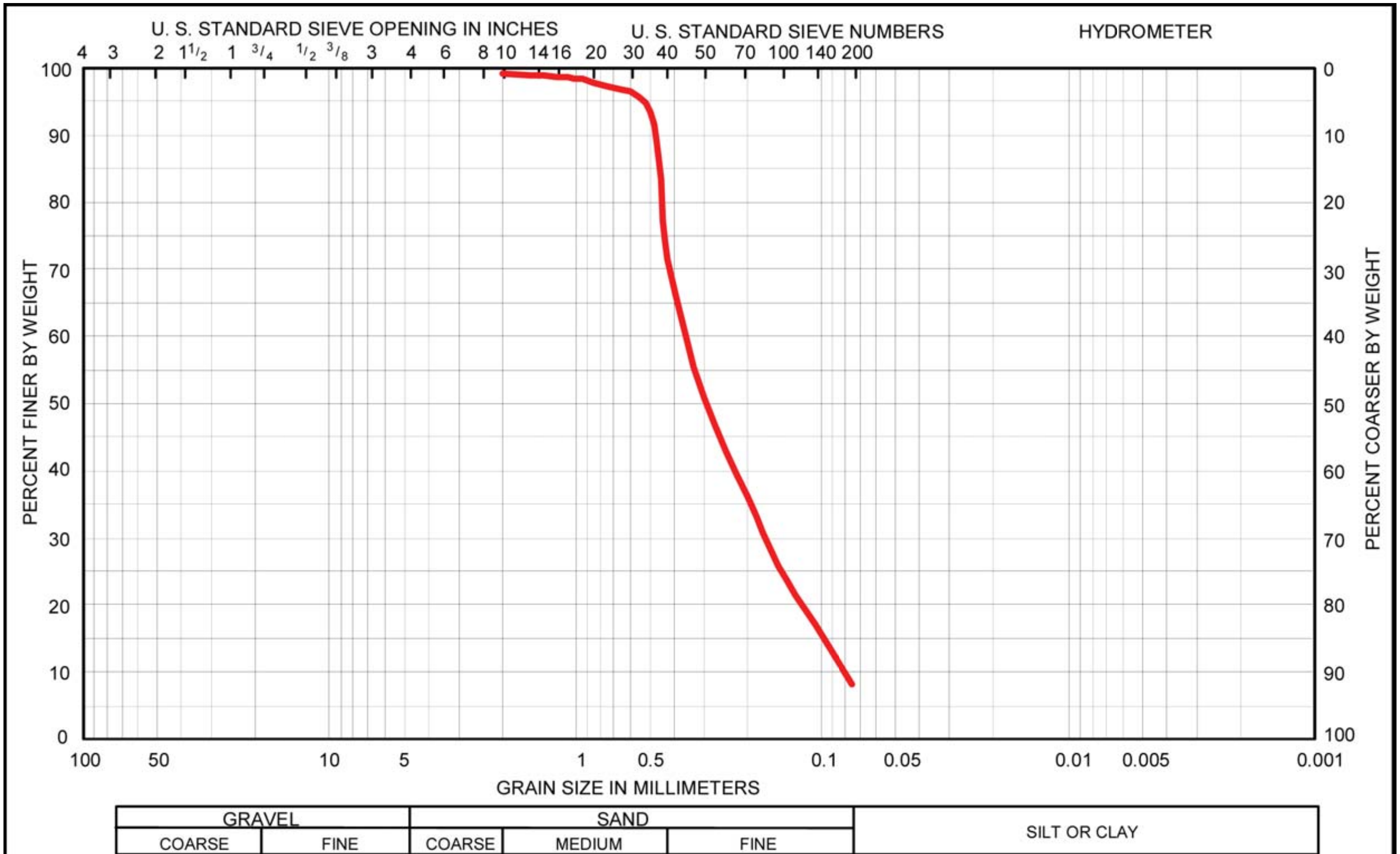
Soil samples

Test specimens were prepared in 6-in. by 6-in. square molds that were 2 in. deep (Photo 1). The soil used for each test was a material from Yuma, AZ. The grain size distribution curve for the soil is given in Figure 1. The soil was classified as poorly graded sand, SP, according to the Unified Soil Classification System. The native material was processed prior to use by oven drying to remove all moisture and then shaking over a No. 16 sieve to remove any large soil grains.

Product application device

Small test specimens were needed to produce the large quantity needed within a reasonable time. Concern was generated among researchers that uniformity would be difficult to achieve with these small samples. A spray device was designed and fabricated that would give uniform application that was consistent among samples. Additionally, it was important that the equipment be capable of achieving volumetric and geometric spray profiles similar to field application equipment. The following text describes the application device and its use.

All soil samples were sprayed with a topical application of the liquid dust palliative at a specified application rate. Three samples were placed into a polyethylene trough designed to collect overspray (Photo 2). The liquid dust palliative was diluted (if stated) and poured into an aluminum canister. The canister was equipped with a ball valve and plastic, 1.5 gal/min, wide fan spray nozzle on the bottom (Photo 3). The top of the canister had a port for attaching an air hose to pressurize the canister and achieve the necessary fan width from the spray nozzle. This system required calibration because higher viscosity liquids required greater pressures to obtain



SAMPLE NO.	MATERIAL	CLASSIFICATION	NAT W%	LL	PL	PI
1	Yuma Sand	Poorly Graded Silty Sand (SP-SM)		NP		

GRADATION CURVES

PROJECT **USMC Dust Abatement**

SOURCE Yuma, Arizona

Figure 1. Grain size distribution of Yuma sand.

equal flow rates. The canister was mounted onto a carriage attached to a transfer mechanism (Photo 4). Uniform displacement rates were achieved using a rack and pinion system powered by a variable-speed DC motor. Travel speeds were adjusted using a rheostat and dial gauge to obtain calibration for achieving the desired application rates based on both speed and volumetric output. Application rates were recorded in gallons per square yard (gsy). Rates of 0.4 and 0.8 gsy were used in this evaluation.

Curing mechanism

Samples were placed under infrared lamps and adjusted to a height that would produce surface temperatures of 120°F (49°C) for curing (Photo 5). The curing simulation was necessary to determine the duration that products require before use and any changes in their properties that may develop over time. Emulsified products require that the water evaporate from the system in order to achieve the expected level of performance. Other products may undergo changes in properties after interacting with the soil for longer periods of time. Samples were tested after 1 hr and 48 hr of curing time. One hour was expected to provide judgment for immediate performance. Samples cured for 48 hr were considered to be fully cured.

Air impingement chamber

Samples were tested in a chamber designed to simulate wind velocities encountered near aircraft. The testing chamber was 4 ft long, 1 ft wide, and 2 ft tall (Photo 6). The chamber was sealed from external air to prevent dust from escaping during testing. Air velocities of 150 mph were generated by an electric fan motor and transmitted through a 3-in. PVC pipe to a rectangular aperture 4-1/2 in. wide and ½-in. tall (Photo 7). Average maximum air velocities were measured using a Kurz Model 2442 anemometer. A return air duct circulated air from the testing chamber to the electric fan to equilibrate pressure. Air blasts were initiated 1 in. above the sample at an angle of 20 deg from horizontal and lasted for 30 sec. Additionally, during the air impingement test, 300 g of Ottawa (20 to 30) sand was injected into the air stream. The sand injection increased surface scour and was intended to replicate actual conditions during aircraft landings as particles impart additional abrasion to the ground surface. Choosing Ottawa sand provided a uniform, consistent material for testing.

Wheel load simulation

Some chemicals used as dust palliatives derive performance from their ability to bind soil grains with adhesives that provide tensile strength. These chemicals have the potential to form a hardened crust on the surface of the soil that is capable of resisting wind erosion. However, the performance of these types of chemicals may not be accurately identified through laboratory testing. Rotary-wing aircraft landing on unpaved soils treated with dust palliative carry heavy loads. The soils they are landing on often have little strength. Landing gear may penetrate the bound surface layer and expose untreated soil beneath. Subsequent landings are impacted by this untreated soil and potentially by large pieces of bound soil that may become entrained in the rotor wash of the aircraft.

A laboratory device was fabricated that was able to simulate surface depressions made by wheeled landing gear during aircraft landings. The device used a curved metal footprint to press into the soil to a depth of 1/2 in. This depth reflects the typical penetration achieved by most dust palliatives and allowed for full penetration of the treated soil. Three samples were disturbed in this manner to compare with the three undisturbed samples. Some depressions caused untreated soil to be exposed on the sample. This phenomenon was similar to results observed during field testing (Rushing et al. 2006). Results described in this document will refer to samples as *trafficked* and *untrafficked*. *Trafficked* samples were those subjected to the wheel load simulation procedure.

Data collection

Erosion potential

Samples were evaluated on their ability to resist surface erosion during the testing sequence. Quantification of this test method was achieved by weighing samples before and after they were subjected to the air impingement test. The mass of soil displaced from the sample was considered to be an indication of anticipated performance for dust mitigation. Dust palliatives that prevented surface erosion were expected to perform well in field conditions. Products with little resistance to wind erosion would disintegrate rapidly during the test. This method was used to determine the relative effectiveness of dust palliatives and to identify quantities of palliative necessary to provide acceptable levels of dust mitigation.

Optical dust concentration measurements

Dust concentrations within the testing chamber were recorded using a HAZDUST III personal dust monitor. The HAZDUST III uses optical techniques to record dust concentrations in the air. The monitor can detect dust particles from 0 to 100 microns at concentrations up to 200 mg/m^3. Measurements were recorded at 1-sec intervals and stored on the internal computer. Data were collected during the 30 sec of air impingement as well as an additional 120 sec subsequent to the air impingement to observe the rate of settling of dust within the testing chamber. Dust concentrations reported in this document are the maximum value obtained by the sensor during testing.

4 Experimental Results and Data Analysis

Erosion potential data

Erosion potential data for each testing combination are given in Tables 1 through 6. The mean of the three samples as well as the standard deviation of the data is provided. Products are ranked in order of effectiveness.

Table 1. Average weight loss (g) for 0.2 gsy, 1 hr cure.

Untrafficked			Trafficked		
Palliative	Mean	Std Dev	Palliative	Mean	Std Dev
DC 100	2.0	2.7	DC 100	18.8	31.9
LDC	2.1	0.8	Soiltac	246.4	237.1
Soil~Sement	3.0	1.2	LDC	260.5	308.1
Soiltac	5.7	4.1	Helotron	384.0	121.5
EK-35	6.9	1.1	Envirotac II	579.9	102.7
Envirotac II	35.0	13.1	Soil~Sement	587.5	192.1
Helotron	37.3	5.9	EK-35	722.2	224.1
Magnesium chloride	102.2	109.5	Envirokleen	788.9	6.9
Durasoil	289.2	411.9	Calcium chloride	822.8	160.1
Envirokleen	418.8	322.8	Durasoil	878.8	109.9
Glycerol	474.3	175.7	Dust Fyghter	890.0	270.9
Surtac	498.1	520.5	Magnesium chloride	918.7	59.1
Calcium chloride	866.3	166.0	Surtac	930.4	56.9
Dust Fyghter	1066.0	278.3	Glycerol	945.4	310.2
RDC-600	1275.0	103.3	RDC-600	1339.2	63.8
Control	1849.4	15.4	Control	1849.4	15.4

Table 2. Average weight loss (g) for 0.2 gsy, 48 hr cure.

Untrafficked			Trafficked		
Palliative	Mean	Std Dev	Palliative	Mean	Std Dev
Magnesium Chloride	0.4	0.2	Soiltac	10.0	13.6
Soil~Sement	2.9	3.2	LDC	15.0	12.6
LDC	3.9	5.2	DC 100	27.8	11.9
DC 100	4.1	3.6	Magnesium chloride	139.2	136.7
Soiltac	6.1	6.6	Calcium chloride	214.9	274.0
Durasoil	108.2	82.6	Durasoil	255.6	85.6
Envirotac II	109.1	117.2	Envirokleen	290.2	97.1
Helotron	147.4	127.8	Envirotac II	354.0	188.1
Envirokleen	313.2	82.3	Soil~Sement	371.0	116.8
EK-35	542.7	568.2	Helotron	549.4	127.8
Calcium chloride	672.7	639.5	EK-35	623.4	229.1
Dust Fyghter	746.5	250.2	Dust Fyghter	811.6	202.7
Glycerol	792.7	615.2	Surtac	1111.7	369.5
Surtac	935.2	155.8	Glycerol	1223.8	304.3
RDC-600	1512.8	64.7	RDC-600	1479.1	44.0
Control	1849.4	15.4	Control	1849.4	15.4

Table 3. Average weight loss (g) for 0.4 gsy, 1 hr cure.

Untrafficked			Trafficked		
Palliative	Mean	Std Dev	Palliative	Mean	Std Dev
EK-35	10.7	4.1	Envirotac II	101.6	18.6
Envirokleen	27.3	30.4	DC 100	122.5	164.1
DC100	41.4	52.1	RDC-600	466.9	166.1
RDC600	46.4	10.1	Surtac	625.2	204.2
Calcium chloride	369.6	339.5	Envirokleen	709.5	359.3
Glycerol	410.8	469.2	Magnesium chloride	783.7	636.3
Helotron	469.1	84.6	EK-35	831.1	731.8
Durasoil	475.2	262.0	Helotron	910.5	441.5
Envirotac II	667.3	552.2	Durasoil	910.7	177.9
Surtac	722.6	632.6	Soil~Sement	1037.7	214.4
Magnesium chloride	859.6	731.7	Soiltac	1163.3	50.2
Soiltac	1141.8	162.8	Dust Fyghter	1165.2	372.2
Soil~Sement	1223.4	70.5	Calcium chloride	1247.1	379.8
Dust Fyghter	1257.1	405.1	LDC	1305.0	163.0
LDC	1413.3	86.4	Glycerol	1331.0	199.0
Control	1849.4	15.4	Control	1849.4	15.4

Table 4. Average weight loss (g) for 0.4 gsy, 48 hr cure.

Untrafficked			Trafficked		
Palliative	Mean	Std Dev	Palliative	Mean	Std Dev
Magnesium chloride	2.5	2.2	Envirotac II	10.3	1.0
Surtac	2.5	0.5	Magnesium chloride	77.7	21.8
Envirotac II	6.0	5.7	Surtac	101.7	22.4
Helotron	8.5	13.6	DC 100	122.2	79.2
Calcium chloride	16.0	23.0	Dust Fyghter	139.5	77.8
DC 100	75.5	49.5	Soiltac	181.3	42.1
Soiltac	211.0	70.1	Helotron	224.6	52.2
LDC	235.5	99.5	LDC	298.0	37.6
Durasoil	315.9	139.5	EK-35	331.7	546.9
Glycerol	367.4	558.6	Calcium chloride	377.9	355.5
Soil~Sement	446.1	171.3	Durasoil	507.7	261.1
Envirokleen	575.1	821.7	Soil~Sement	566.3	69.6
Dust Fyghter	613.6	491.5	Envirokleen	620.8	604.0
EK-35	783.8	660.5	Glycerol	1399.9	127.0
RDC-600	1509.7	25.3	RDC-600	1749.2	84.6
Control	1849.4	15.4	Control	1849.4	15.4

Table 5. Average weight loss (g) for 0.8 gsy, 1 hr cure.

Untrafficked			Trafficked		
Palliative	Mean	Std Dev	Palliative	Mean	Std Dev
DC 100	5.9	2.6	DC 100	12.0	10.2
Magnesium chloride	17.1	5.5	RDC-600	32.0	1.5
RDC-600	22.1	1.1	Surtac	35.8	8.4
Dust Fyghter	22.7	3.4	Helotron	46.7	21.8
Calcium chloride	24.7	5.6	Glycerol	51.7	13.6
Surtac	30.2	2.4	Envirotac II	82.5	23.0
LDC	32.6	17.2	Magnesium chloride	117.2	180.9
Helotron	32.6	15.7	LDC	128.3	156.8
Glycerol	47.9	9.2	Dust Fyghter	328.9	372.1
Envirokleen	56.5	13.1	Calcium chloride	335.0	511.8
Envirotac II	70.8	56.5	Soiltac	369.2	634.5
Durasoil	233.8	311.5	Durasoil	688.9	571.1
Soiltac	280.8	479.5	Soil~Sement	695.9	561.4
Soil~Sement	312.4	489.8	Envirokleen	825.4	698.1
EK-35	595.9	695.2	EK-35	867.6	261.5
Control	1849.4	15.4	Control	1849.4	15.4

Table 6. Average weight loss (g) for 0.8 gsy, 48 hr cure.

Untrafficked			Trafficked		
Palliative	Mean	Std Dev	Palliative	Mean	Std Dev
Helotron	0.4	0.2	Envirotac II	1.5	0.8
Magnesium chloride	0.5	0.2	DC 100	4.4	3.6
Soiltac	0.5	0.3	Soiltac	9.9	11.3
Calcium chloride	1.4	0.5	Magnesium chloride	11.7	16.9
Envirotac II	2.6	3.9	LDC	14.7	2.3
Surtac	3.4	1.9	Calcium chloride	36.4	18.9
Dust Fyghter	4.9	5.1	Soil~Sement	41.1	16.8
DC 100	6.9	7.2	Surtac	104.5	50.2
Soil~Sement	9.3	8.2	Dust Fyghter	106.8	21.2
LDC	9.6	5.4	Helotron	121.2	19.3
EK-35	18.3	2.2	Envirokleen	160.8	81.0
Glycerol	33.6	11.2	Durasoil	174.7	79.2
Envirokleen	180.9	131.6	Glycerol	310.7	458.7
Durasoil	239.6	298.0	EK-35	378.6	529.4
RDC-600	982.7	164.9	RDC-600	1481.4	106.6
Control	1849.4	15.4	Control	1849.4	15.4

Optical dust concentration measurements

Dust concentration data for each testing combination are given in Tables 7 through 12. The mean of the three samples as well as the standard deviation of the data is provided. Products are ranked in order of effectiveness.

Table 7. Maximum dust concentration (mg/m³) for 0.2 gsy, 1 hr cure.

Untrafficked			Trafficked		
Palliative	Average	Std Dev	Palliative	Average	Std Dev
LDC	0.81	0.15	Magnesium chloride	3.13	0.95
Helotron	1.12	0.10	LDC	3.64	2.54
Soiltac	1.26	0.19	DC 100	5.38	2.74
DC 100	2.68	1.90	Helotron	11.43	4.44
Envirotac II	2.86	1.03	Envirokleen	14.18	2.08
Soil~Sement	2.97	1.79	Soiltac	14.52	6.67
EK 35	4.37	1.82	Soil~Sement	18.46	5.21
Magnesium chloride	5.29	6.91	EK 35	20.96	11.12
Envirokleen	10.08	3.12	Durasoil	25.50	3.87
Durasoil	10.89	13.06	Dust Fyghter	26.06	9.35
Glycerol	22.50	10.56	Envirotac II	29.44	4.57
Calcium chloride	28.26	22.96	Glycerol	34.90	13.06
Surtac	55.36	65.78	Calcium chloride	37.86	13.02
Dust Fyghter	57.07	50.82	RDC 600	46.04	4.56
RDC 600	57.12	13.63	Surtac	64.57	17.97
Control	110.27	24.74	Control	110.27	24.74

Table 8. Maximum dust concentration (mg/m³) for 0.2 gsy, 48 hr cure.

Untrafficked			Trafficked		
Palliative	Average	Std Dev	Palliative	Average	Std Dev
Soiltac	1.00	0.21	Soiltac	1.12	0.38
LDC	1.17	0.18	LDC	1.17	0.18
Soil~Sement	1.25	0.13	DC 100	5.08	1.52
Magnesium chloride	3.19	0.75	Soil~Sement	5.40	1.31
Durasoil	3.83	3.46	Durasoil	8.79	2.88
Helotron	6.25	5.09	Magnesium chloride	11.11	4.27
EK 35	10.64	8.08	Envirokleen	14.15	4.38
Envirotac II	12.38	9.97	EK 35	16.27	9.57
Envirokleen	18.05	2.68	Calcium chloride	20.95	16.34
DC 100	23.88	35.80	Envirotac II	31.81	15.49
Dust Fyghter	31.31	5.05	Dust Fyghter	35.17	8.08
Calcium chloride	33.89	27.00	Helotron	40.00	51.35
Glycerol	47.39	9.83	Glycerol	45.77	15.18
RDC 600	85.34	6.16	RDC 600	70.24	3.15
Surtac	87.70	25.47	Surtac	106.20	65.57
Control	110.27	24.74	Control	110.27	24.74

Table 9. Maximum dust concentration (mg/m³) for 0.4 gsy, 1 hr cure.

Untrafficked			Trafficked		
Palliative	Average	Std Dev	Palliative	Average	Std Dev
RDC-600	2.03	0.79	Envirotac II	5.55	0.15
Envirokleen	2.20	1.6	DC 100	7.03	4.19
EK-35	3.17	3.8	Durasoil	8.96	2.29
DC 100	4.75	1.44	RDC-600	11.48	2.37
Durasoil	7.15	2.28	Envirokleen	12.16	5.55
Glycerol	14.88	12.51	Magnesium chloride	12.94	7.63
Helotron	15.75	1.92	EK-35	13.65	8.79
Calcium chloride	16.11	9.55	Surtac	14.75	3.89
Envirotac II	22.87	13.78	Soil~Sement	17.46	3.69
Soil~Sement	22.87	3.75	Helotron	22.35	11.76
Magnesium chloride	23.59	19.22	Soiltac	28.22	7.77
Soiltac	33.59	11.71	Dust Fyghter	29.68	21.9
Surtac	34.26	30.43	Calcium chloride	31.15	14.27
Dust Fyghter	38.25	14.45	LDC	40.39	10.47
LDC	60.04	24.16	Glycerol	58.13	26.25
Control	110.27	24.74	Control	110.27	24.74

Table 10. Maximum dust concentration (mg/m³) for 0.4 gsy, 48 hr cure.

Untrafficked			Trafficked		
Palliative	Average	Std Dev	Palliative	Average	Std Dev
Magnesium chloride	1.76	0.18	Magnesium chloride	3.79	0.73
Calcium chloride	1.96	0.92	Surtac	4.53	0.95
Helotron	2.23	0.34	EK-35	4.68	3.77
Surtac	2.48	0.33	Envirotac II	5.2	0.42
Envirokleen	3.15	0.72	Helotron	6.08	1.19
Envirotac II	4.60	0.38	Soiltac	6.23	1.01
DC 100	7.25	1.08	Dust Fyghter	6.55	3.25
Soiltac	7.74	1.42	DC 100	7.66	1.31
Durasoil	9.21	2.98	Envirokleen	7.85	2.73
Soil~Sement	9.27	2.78	Durasoil	9.67	2.54
LDC	10.67	1.68	Soil~Sement	11.34	1.2
Glycerol	13.78	11.10	LDC	11.76	1.23
EK-35	15.72	17.94	Calcium chloride	11.8	9.94
Dust Fyghter	25.74	20.66	Glycerol	42.55	19.42
RDC-600	37.14	5.54	RDC-600	56.57	6.24
Control	110.27	24.74	Control	110.27	24.74

Table 11. Maximum dust concentration (mg/m³) for 0.8 gsy, 1 hr cure.

Untrafficked			Trafficked		
Palliative	Average	Std Dev	Palliative	Average	Std Dev
Helotron	1.18	0.40	Helotron	1.67	1.17
Dust Fyghter	1.34	0.30	Surtac	1.99	0.31
Surtac	1.40	0.12	RDC-600	2.02	0.15
RDC-600	1.97	0.40	DC 100	4.47	0.08
LDC	2.27	0.25	Glycerol	4.71	0.93
Magnesium chloride	3.27	0.52	LDC	5.18	2.72
Envirokleen	3.33	0.56	Magnesium chloride	5.79	3.52
Calcium chloride	3.59	0.66	Dust Fyghter	6.11	4.16
Glycerol	3.67	0.24	Envirotac II	6.75	1.39
DC 100	4.15	0.12	Soiltac	9.56	9.45
Envirotac II	5.47	0.77	Envirokleen	11.13	7.62
EK-35	6.12	5.63	Soil~Sement	12.33	6.96
Durasoil	6.51	5.68	EK-35	12.55	1.27
Soil~Sement	7.01	7.62	Calcium chloride	13.99	16.3
Soiltac	8.61	10.10	Durasoil	25.65	33.48
Control	110.27	24.74	Control	110.27	24.74

Table 12. Maximum dust concentration (mg/m³) for 0.8 gsy, 48 hr cure.

Untrafficked			Trafficked		
Palliative	Average	Std Dev	Palliative	Average	Std Dev
Calcium chloride	1.21	0.07	Magnesium chloride	1.27	0.22
Magnesium chloride	1.41	0.21	Calcium chloride	1.35	0.13
Soiltac	1.68	0.58	Dust Fyghter	4.1	0.77
Helotron	1.71	0.15	Helotron	4.18	0.42
Dust Fyghter	2.06	0.16	LDC	4.63	0.75
EK-35	2.45	0.24	Envirokleen	4.79	0.63
Soil~Sement	3.34	0.77	Soiltac	4.97	1.48
Glycerol	3.96	0.45	Envirotac II	5.38	1.11
LDC	4.03	0.16	DC 100	5.74	1.32
Envirotac II	4.39	0.63	EK-35	5.95	1.21
DC 100	4.83	0.51	Soil~Sement	6.21	2.28
Surtac	5.17	0.57	Surtac	8.53	1.01
Envirokleen	5.53	2.10	Durasoil	9.57	4.81
Durasoil	5.87	3.16	Glycerol	11.61	10.77
RDC-600	19.82	4.23	RDC-600	38.26	10.23
Control	110.27	24.74	Control	110.273	24.74

Each of the dust palliatives evaluated in this study offers some degree of successful dust mitigation compared with the control section. The relative effectiveness of the products can be determined by the trends exhibited in the data for each testing condition. It was noted that some variation existed within the three replicates for each test. This variation was also related to the performance of the palliative. Products that provided excellent dust mitigation showed little surface erosion during testing. These samples had no noticeable deterioration and little variability. Products offering very poor dust mitigation completely eroded each time, and the variability in these sample sets was also low. In contrast, some products appeared to be marginally effective, having one or two samples that resisted the air impingement, with the others completely deteriorating during the test. This led to an average erosion or dust concentration value nearly equal to that of the standard deviation of the sample set. It was inferred from this behavior that successful and consistent dust mitigation would not be achieved with these products applied at the specified application conditions.

Comparison of testing methods

Two data collection systems were used in this experiment to provide additional data and to determine the most accurate way to predict field performance of dust palliatives. Data from the two methods were analyzed using linear regression to evaluate their correlation to one another. Data were separated according to the samples tested using the same application rate, curing time, and traffic condition for this analysis. Results are provided in Figures 2 through 13. Table 13 lists the regression equations for each analysis.

The linear regression analysis of the two data sets from their respective collection methods indicates general trends within each testing condition as well as for the overall experimental matrix. Correlation of the two data sets was performed to validate the testing procedure and to identify inconsistencies within the data set. Neither the soil erosion nor dust concentration measurements had been used previously to quantify dust palliative performance. Obtaining closely related data trends helped to provide confidence in the results.

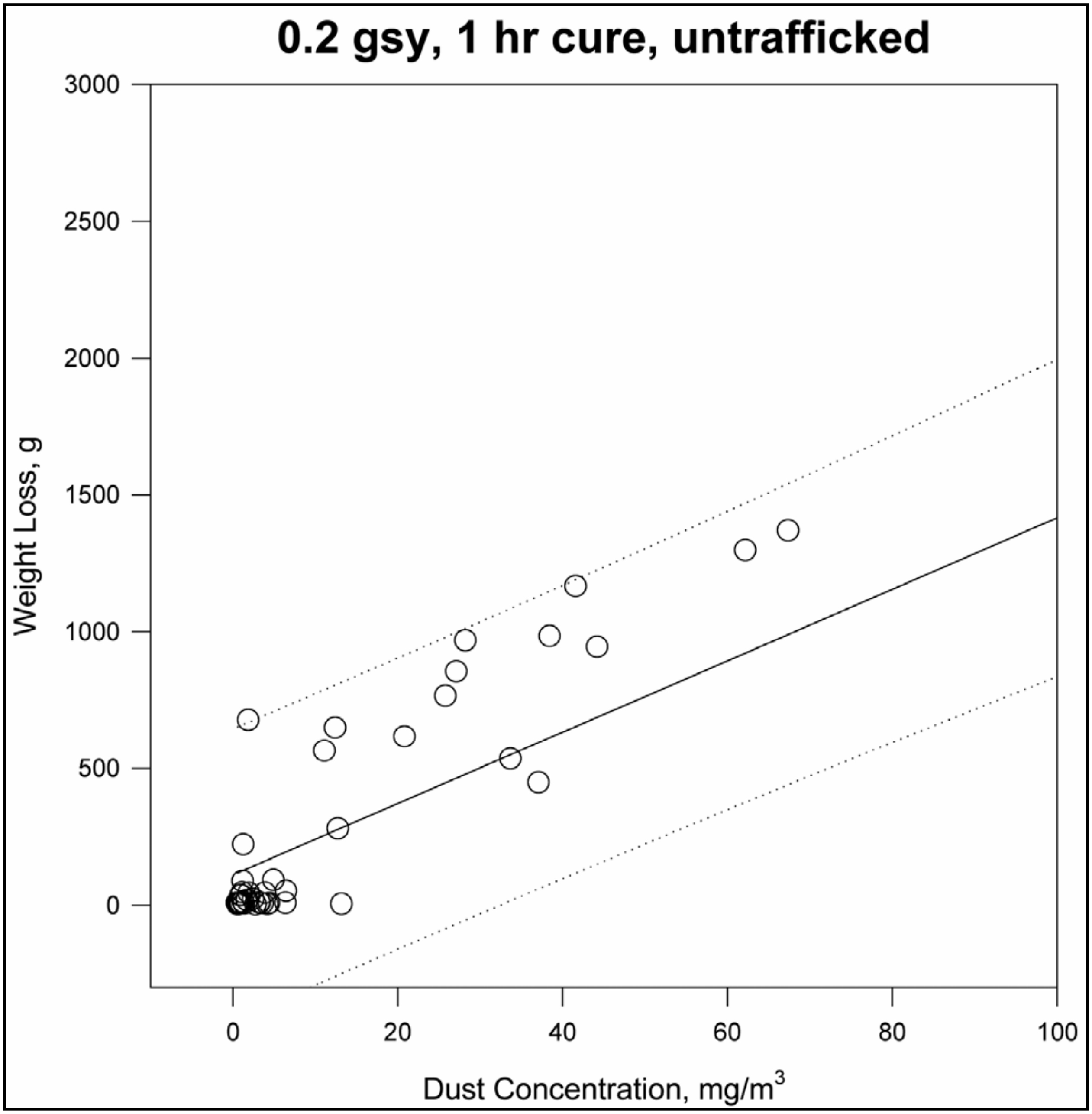


Figure 2. Regression analysis for 0.2 gsy, 1 hr cure, untrafficked samples.

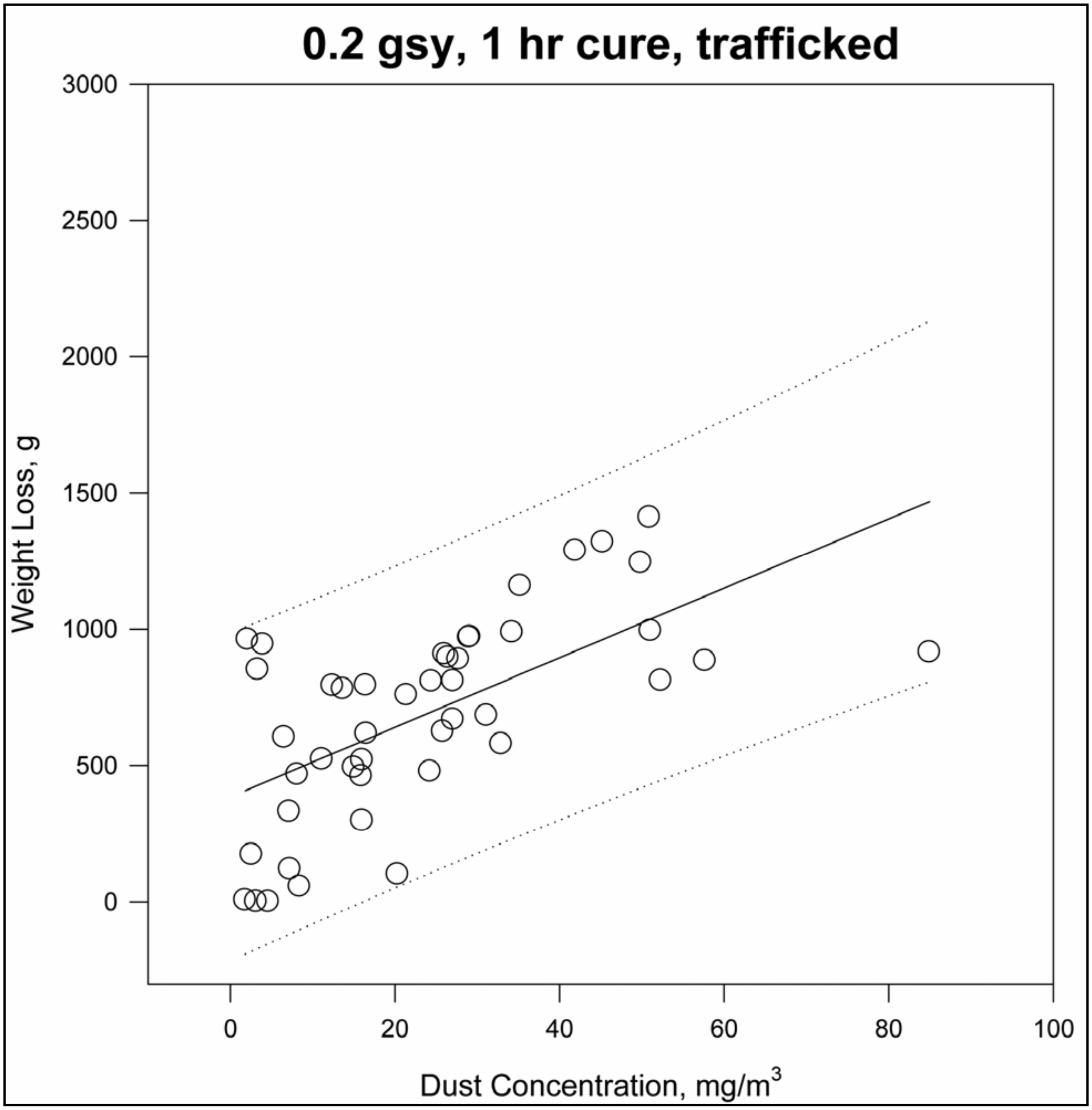


Figure 3. Regression analysis for 0.2 gsy, 1 hr cure, trafficked samples.

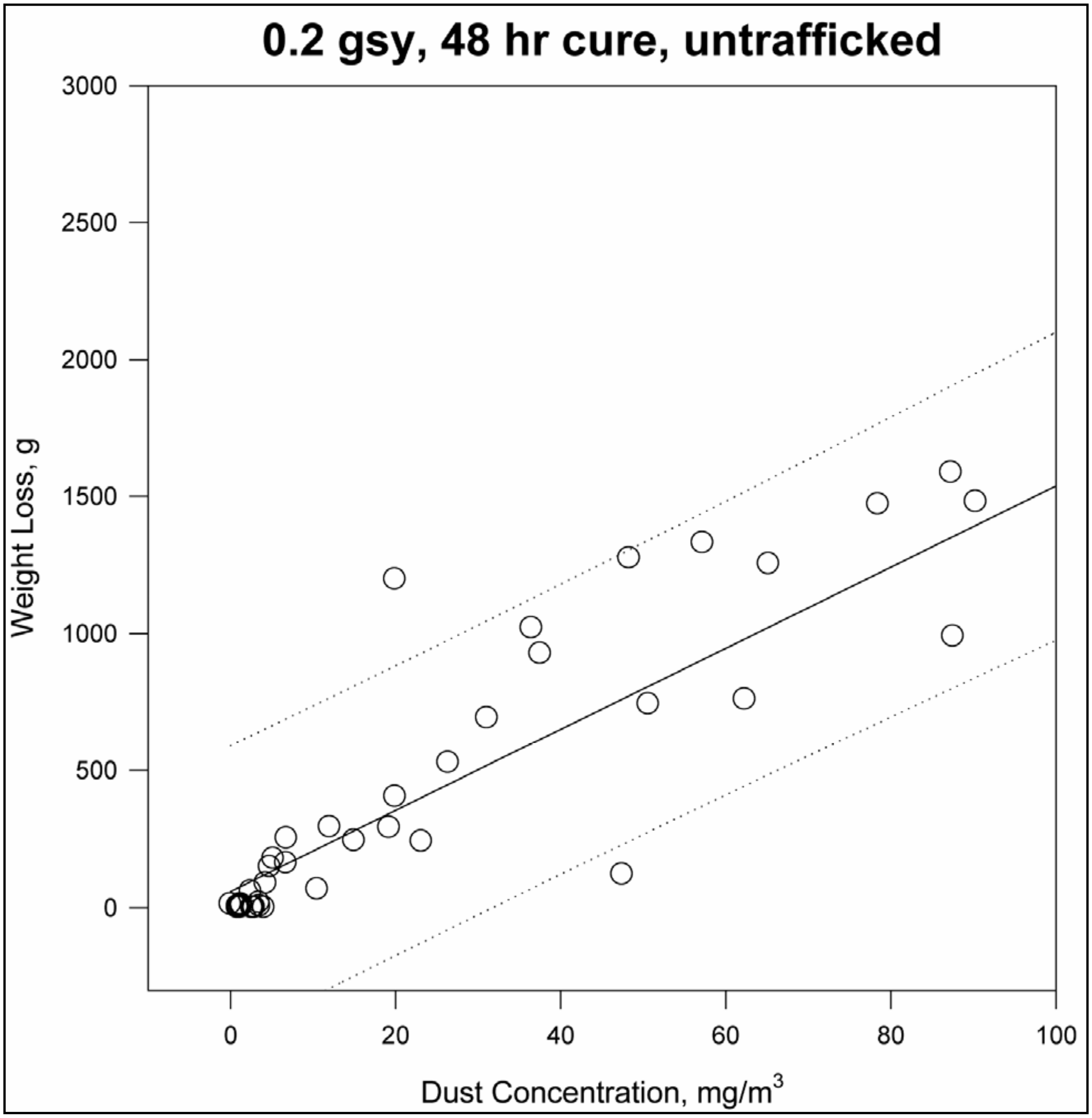


Figure 4. Regression analysis for 0.2 gsy, 48 hr cure, untrafficked samples.

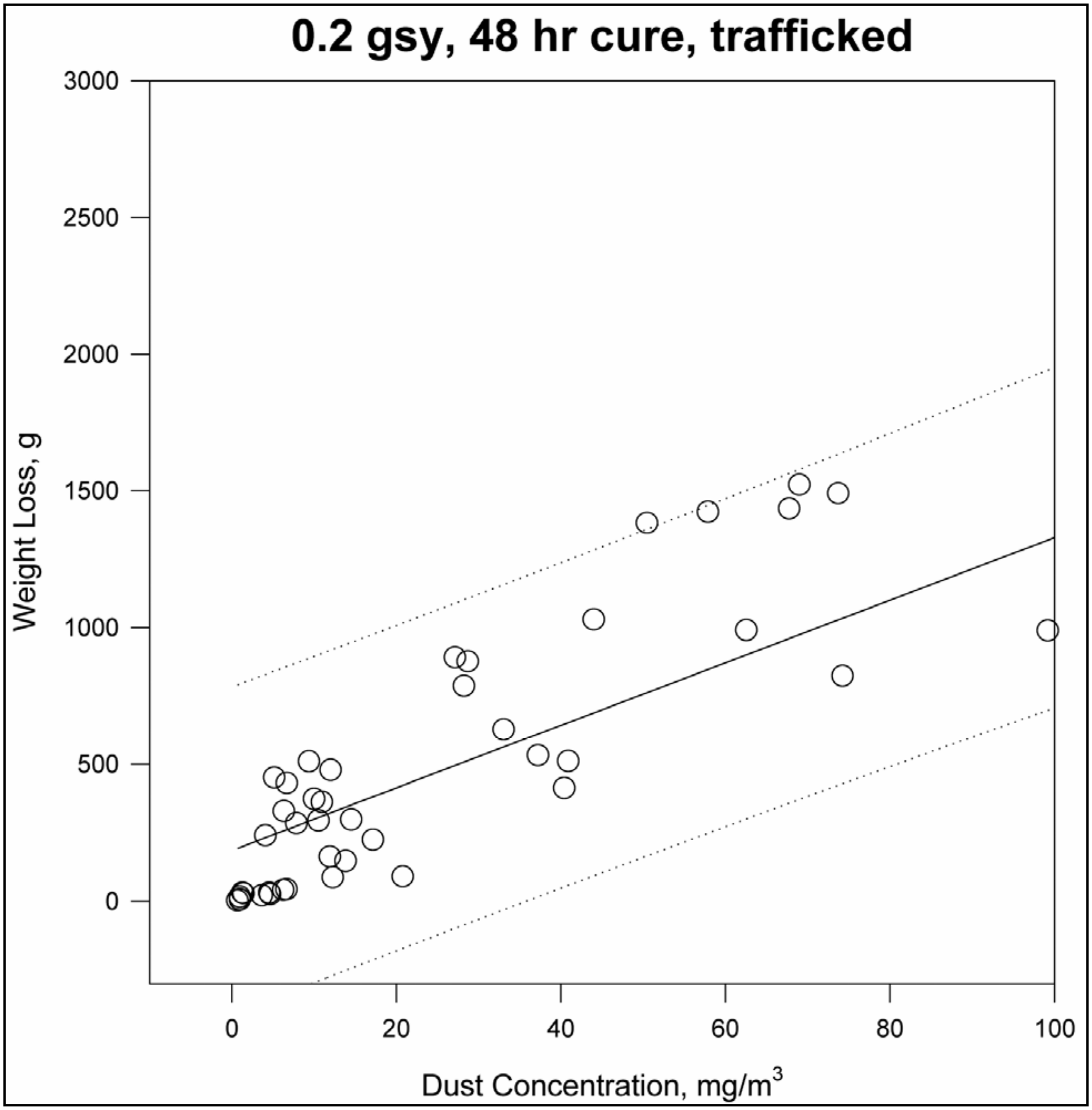


Figure 5. Regression analysis for 0.2 gsy, 48 hr cure, trafficked samples.

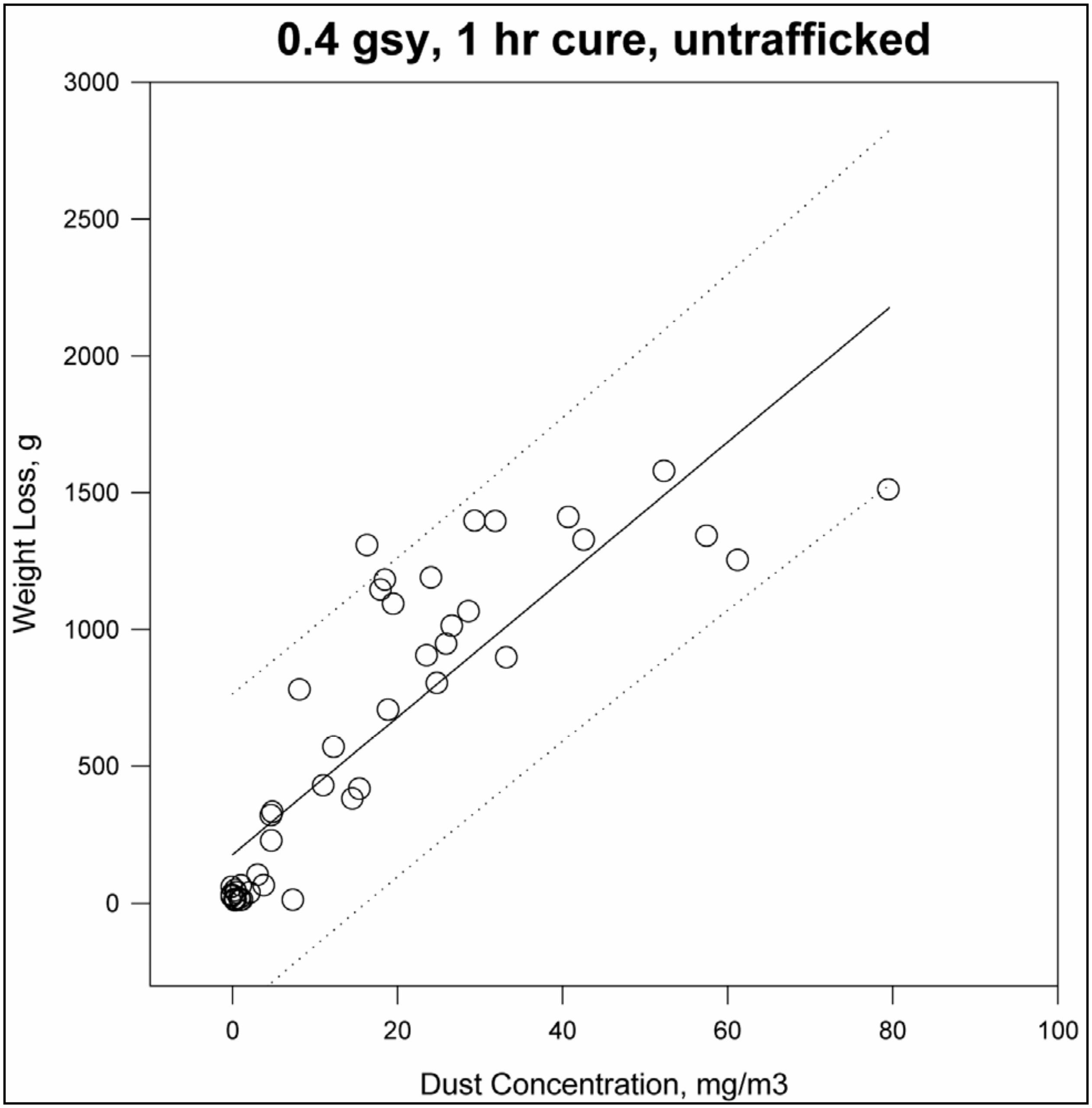


Figure 6. Regression analysis for 0.4 gsy, 1 hr cure, untrafficked samples.

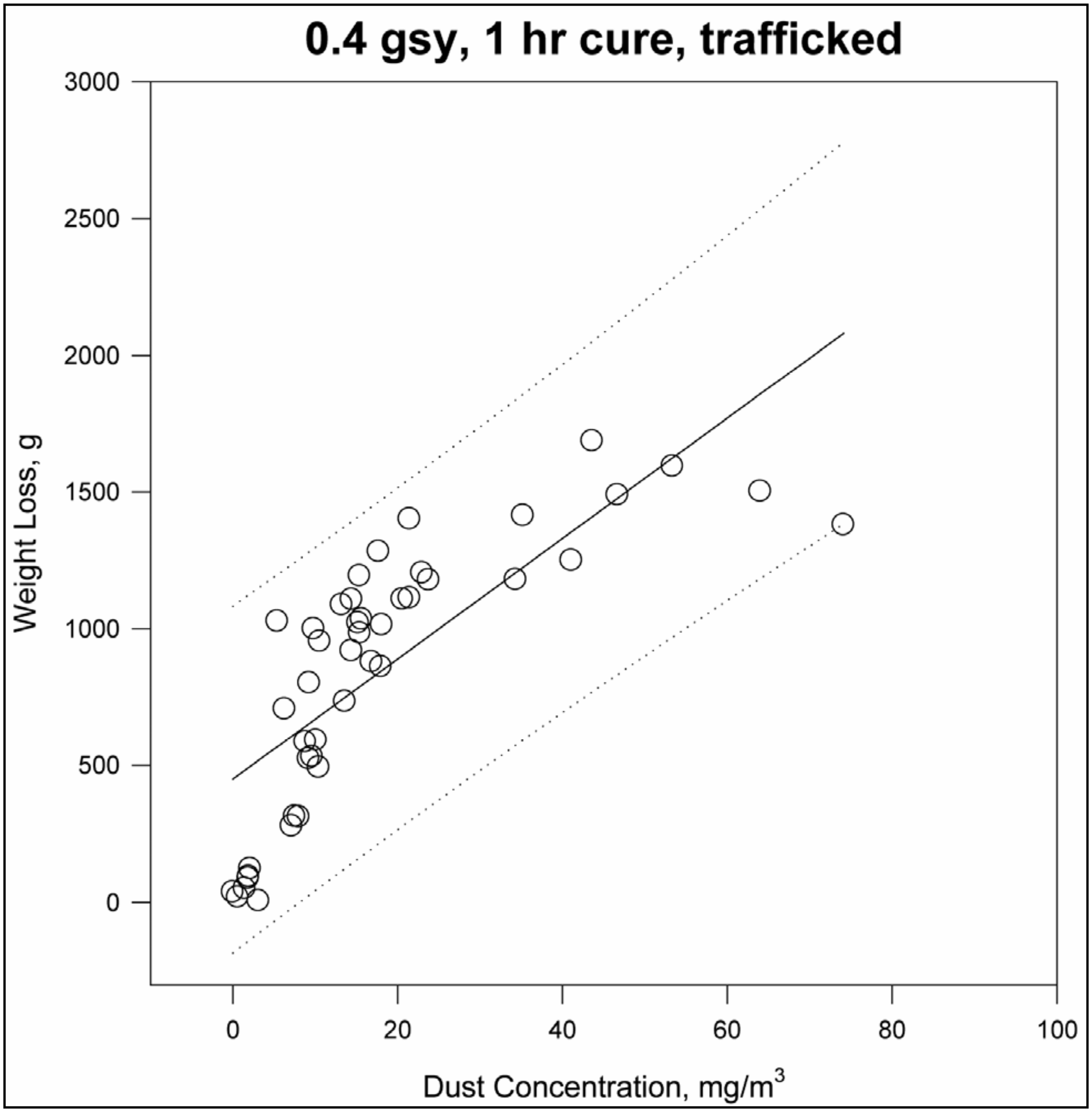


Figure 7. Regression analysis for 0.4 gsy, 1 hr cure, trafficked samples.

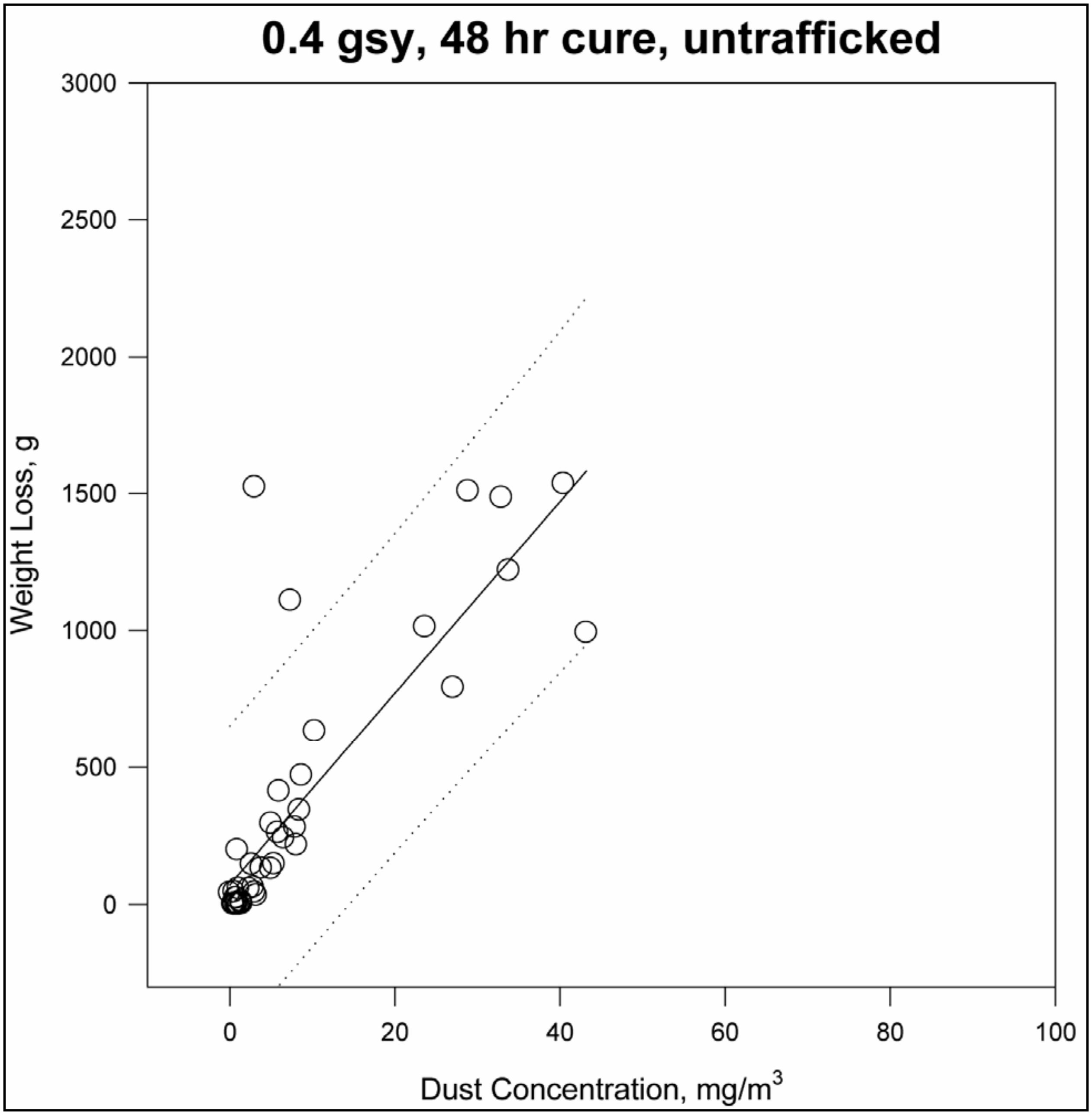


Figure 8. Regression analysis for 0.4 gsy, 48 hr cure, untrafficked samples.

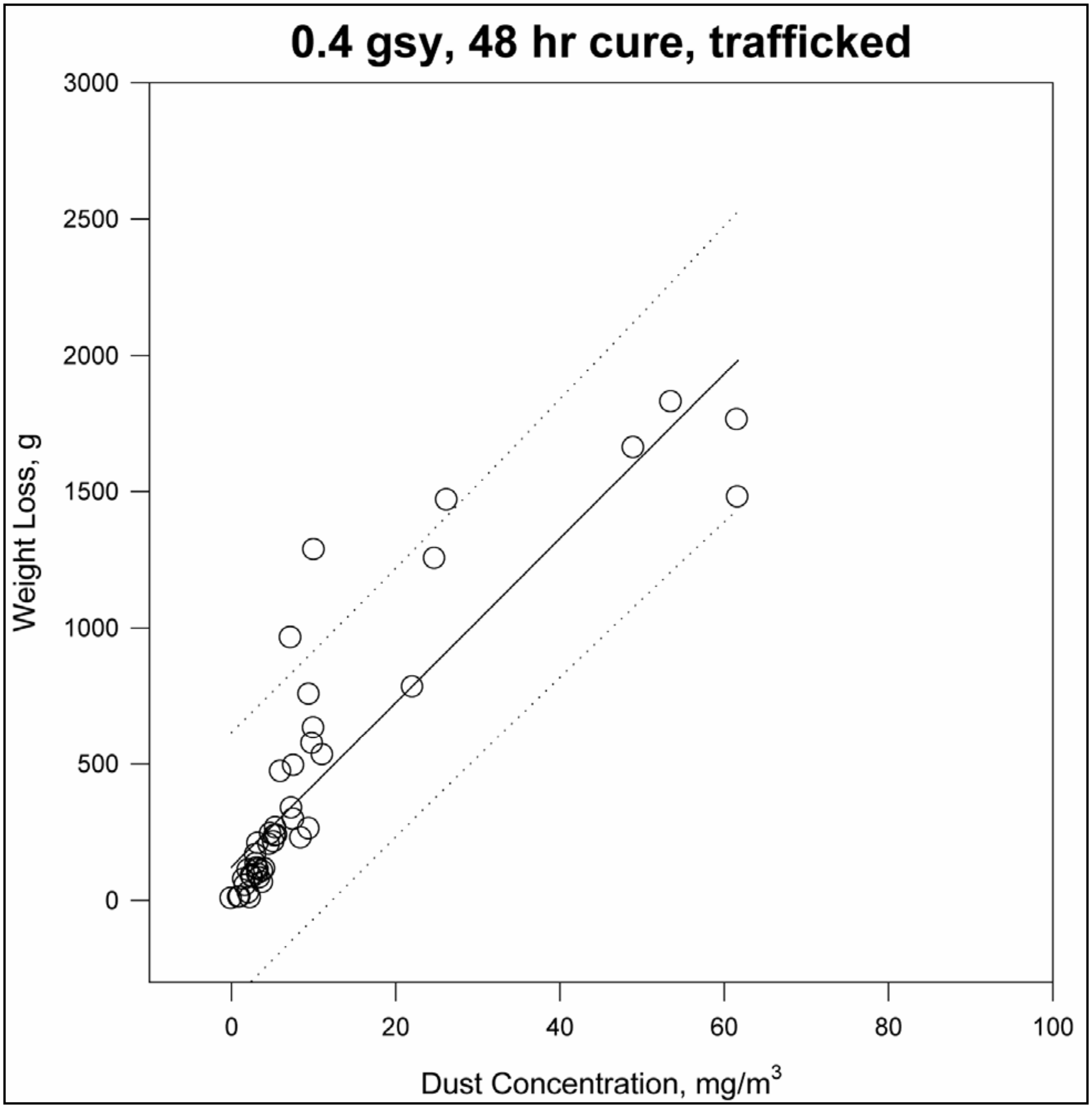


Figure 9. Regression analysis for 0.4 gsy, 48 hr cure, trafficked samples.

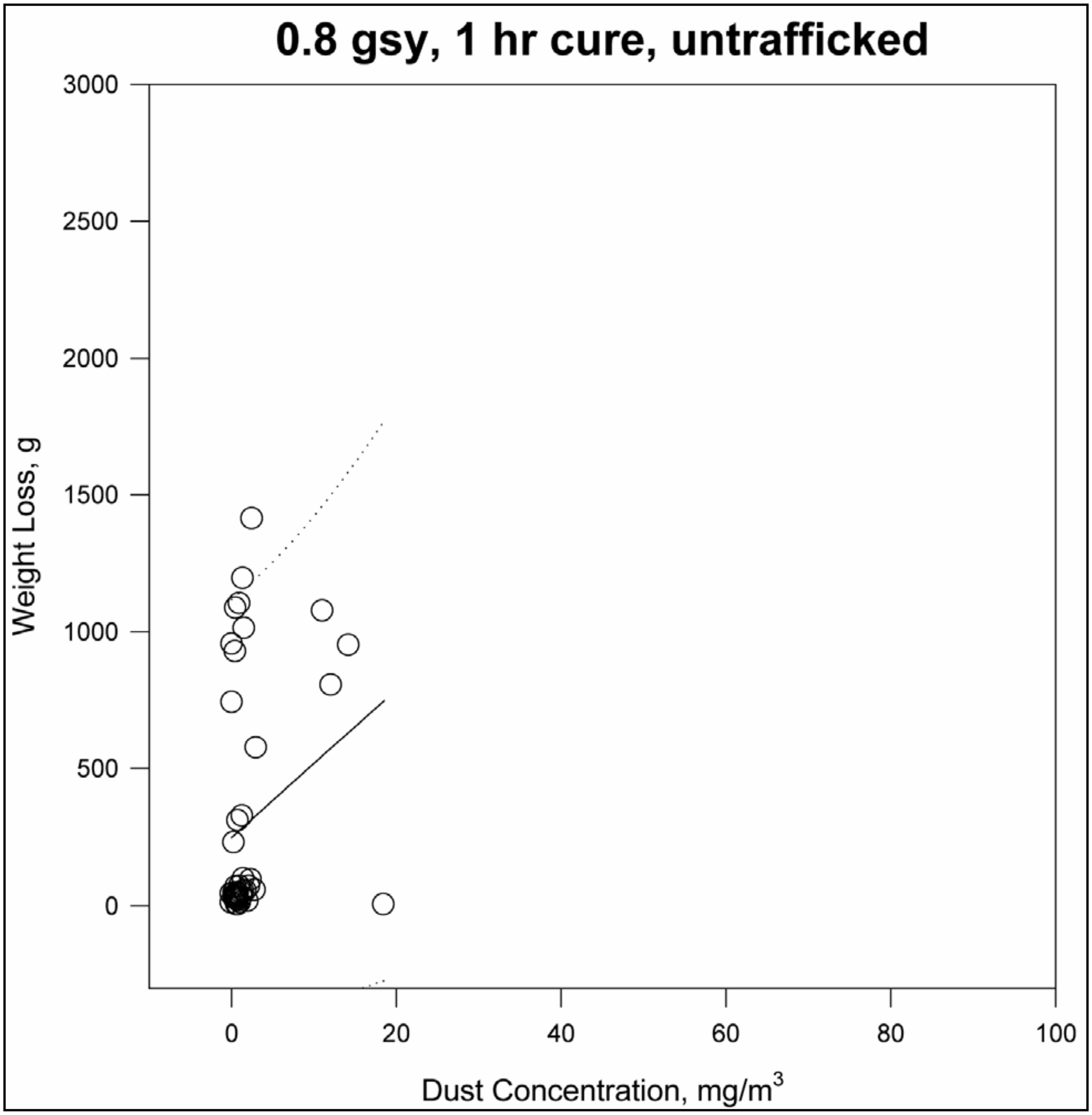


Figure 10. Regression analysis for 0.8 gsy, 1 hr cure, untrafficked samples.

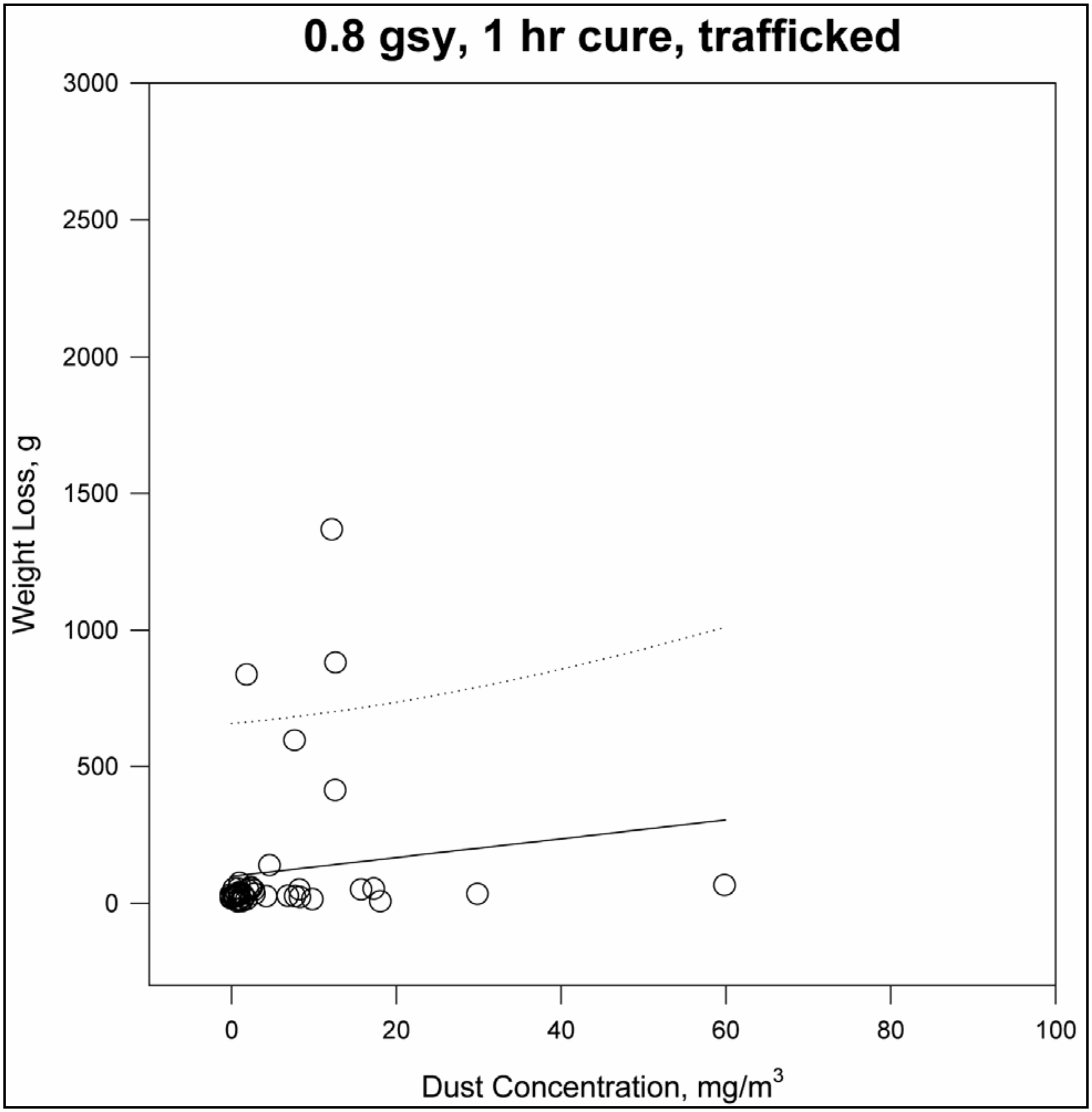


Figure 11. Regression analysis for 0.8 gsy, 1 hr cure, trafficked samples.

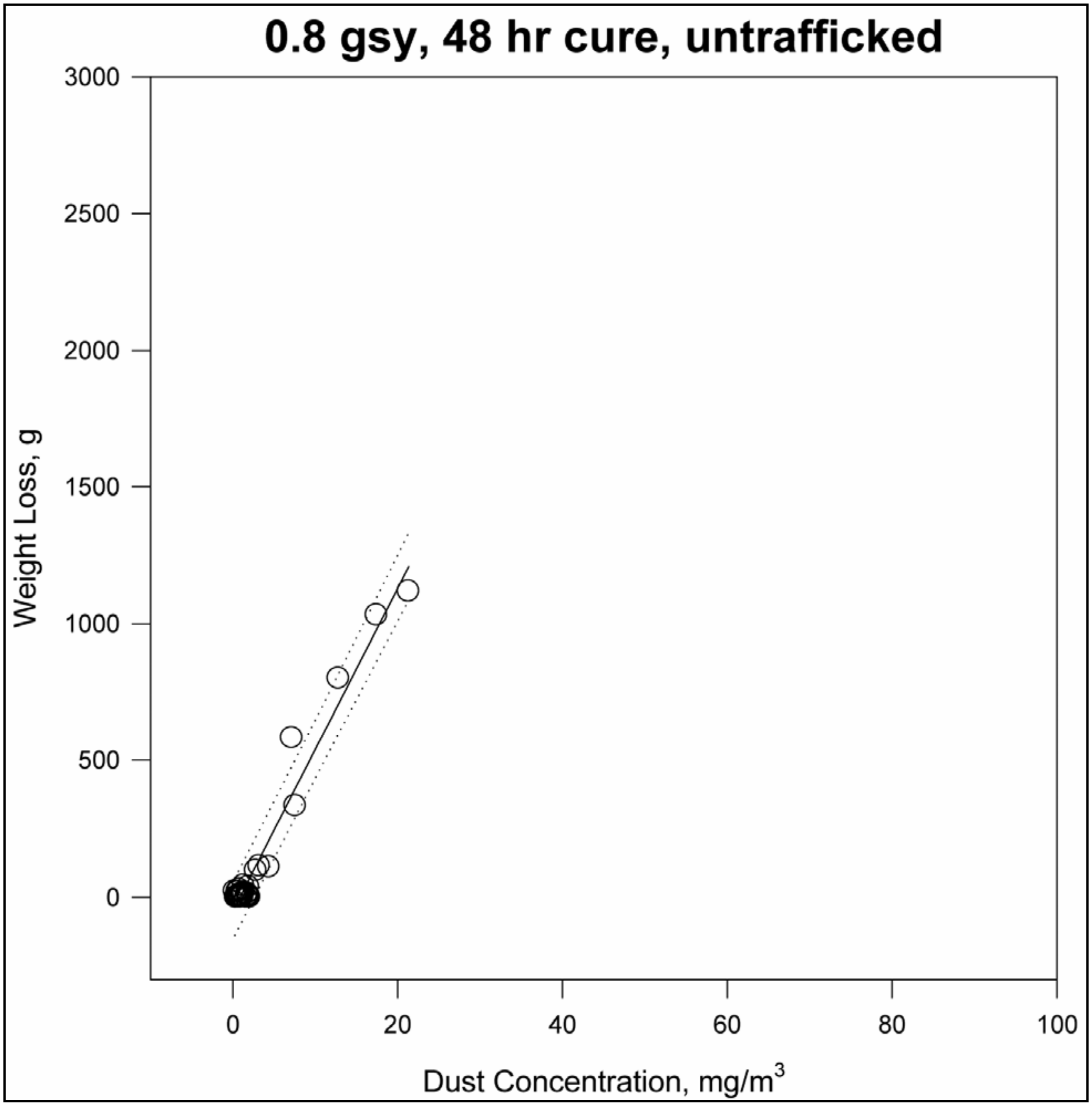


Figure 12. Regression analysis for 0.8 gsy, 48 hr cure, untrafficked samples.

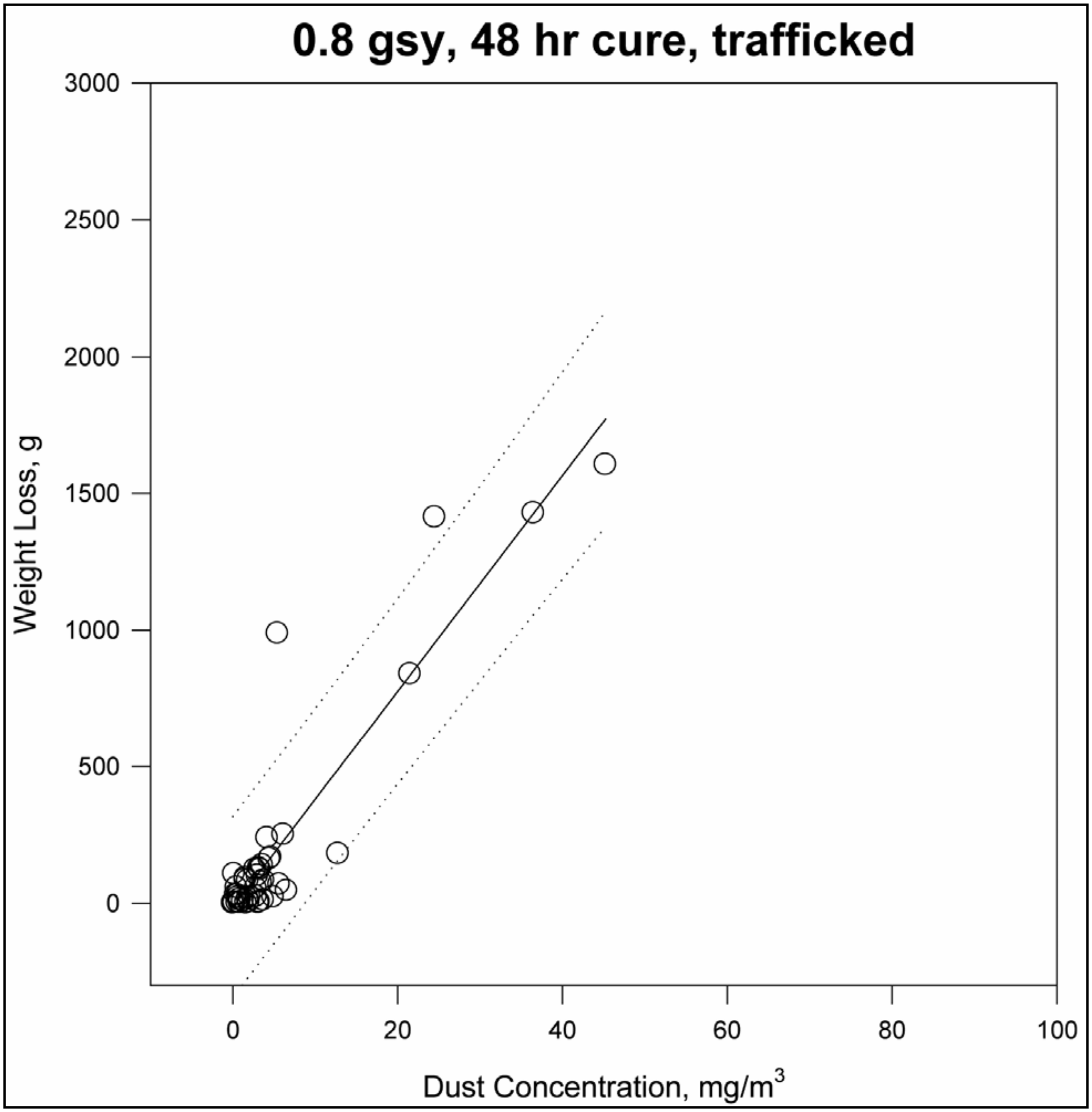


Figure 13. Regression analysis for 0.8 gsy, 48 hr cure, trafficked samples.

Table 13. Regression values for dust collection analysis.

	Slope	Intercept	R^2
0.2, 1 hr, Untrafficked	13.055	110.213	0.675
0.2, 1 hr, Trafficked	12.744	385.065	0.392
0.2, 48 hr, Untrafficked	14.787	58.907	0.756
0.2, 48 hr, Trafficked	11.437	184.616	0.654
0.4, 1 hr, Untrafficked	25.111	177.381	0.741
0.4, 1 hr, Trafficked	22.015	449.179	0.597
0.4, 48 hr, Untrafficked	34.956	72.022	0.675
0.4, 48 hr, Trafficked	30.144	122.396	0.795
0.8, 1 hr, Untrafficked	26.986	248.664	0.059
0.8, 1 hr, Trafficked	3.437	98.325	0.017
0.8, 48 hr, Untrafficked	58.95	-49.905	0.963
0.8, 48 hr, Trafficked	39.481	-14.321	0.836

Both soil erosion and dust concentration data are dependent on the soil used in the experiment. The soil gradation has the largest effect on the results. The weight of the individual soil grains will mainly dictate their resistance to movement from the air impingement test and the rate at which suspended particles settle from the air. The soil used for these experiments consisted of mainly fine sand particles. The minus 200 material was 7 percent. This particular gradation of material provided a granular media with a relatively high surface area. These characteristics were beneficial because product application quantities sufficiently mitigating dust in this soil would be expected to provide acceptable results in other soil types, and this material was noncohesive, which ensured that all tensile forces generated between soil grains were induced by the palliative. The additional benefit of using this soil was related to the optical system for measuring dust concentrations. The relatively small fraction (12 percent according to Figure 1) of the soil within the measuring limitations (100 microns) prevented over-ranging the sensor (200 mg/m^3).

In general, the regression statistic, R^2, increases with cure time under otherwise similar testing conditions. This value also decreases after applying the traffic simulation test. Notable trends are not established for variations in the application rate.

Treated samples that were allowed to cure for 48 hr were expected to provide optimal results. At this point, emulsified products have been able to coalesce and impart tensile forces between soil grains. Non-film-forming products were allowed to penetrate to substantial depths to prevent surface peeling. These conditions most likely led to the increase in the R^2 value obtained from the regression. Samples tested after only 1 hr of curing exhibited some inconsistencies in performance spawned by the incomplete physical changes intended to provide dust mitigation.

The decrease in the R^2 value noted after the traffic simulation test was most likely caused by the fact that the simulation created heterogeneity in the sample. The surface inconsistencies imparted variability into the sample, which was reflected through the data.

The slope of the regression line tended to increase with increasing application rates. The slope of the line would generally be related to the soil gradation used during testing. Soils with higher concentrations of fine materials would have lower slopes because of the limited particle size detectible by the dust sensor. The change in the slope of the line with the increase in application rate suggests that agglomeration of soil particles is occurring during treatment and that the effective soil gradation is changing. Very fine particles are sticking together and forming larger particles. These newly formed particles are not detectible by the dust sensor but are not massive enough to resist dislodging from the sample during air impingement.

Effect of traffic simulation test

Data for both untrafficked and trafficked samples were compared to determine the effect of the traffic simulation on performance for each type of dust palliative. The data for each set of treatment conditions were analyzed statistically using a two-sample t-test with the treatment groups consisting of the sets of samples of which the only variation was if they were subjected to the traffic simulation test. The confidence limit for the analysis was set at 95 percent for all evaluations. Statistical analyses were performed using SigmaStat® software. Results from the analyses are given in Table 14. The presence of the X in the table indicates that a statistical difference did exist between groups exposed to the traffic simulation test and those that were left undisturbed.

Table 14. Statistical differences found between trafficked and untrafficked samples

	Erosion						Sensor					
	1 hr Cure			48 hr Cure			1 hr Cure			48 hr Cure		
	0.2 gsy	0.4 gsy	0.8 gsy	0.2 gsy	0.4 gsy	0.8 gsy	0.2 gsy	0.4 gsy	0.8 gsy	0.2 gsy	0.4 gsy	0.8 gsy
Durasoil												
Envirokleen		X						X				X
Soil~Sement	X			X		X	X			X		
Soiltac							X					
Envirotac II	X						X					
Liquid Dust Control												
Calcium chloride		X				X						
Magnesium chloride	X				X					X	X	
Surtac					X	X					X	X
Glycerol		X			X							
Helotron	X				X	X	X				X	X
DC 100												
Dust Fyghter						X						
EK-35	X											
RDC 600		X	X		X	X		X		X	X	X

The traffic simulation test was developed as a means to evaluate the effect of vehicle traffic on dust-treated surfaces. Field testing of dust palliatives (Rushing et al. 2006) revealed that thin surface crusts may be capable of withstanding wind erosion, but fracture points caused by introducing external loads to these surfaces facilitate rapid deterioration. The test designed for this study applied a vertical load to the surface of the treated soil sample. Those samples with thin, brittle crusts were expected to perform poorly once untreated soil was exposed. Not all samples were expected to be greatly affected by traffic. The analysis of the untrafficked and trafficked data sets attempted to identify the products and application conditions that would be prone to a reduction in performance with imposed traffic.

Statistical differences in the performance of samples related to their traffic condition were dependent on the variance within the data set for that particular sample. Samples with a high variance within either the trafficked or untrafficked data set were not found to be statistically different. This result was unrelated to the traffic simulation. The partial deterioration of these samples rendered them unacceptable for dust mitigation, regardless of traffic condition.

For samples cured only 1 hr, more statistical differences were found at lower application rates. In general, heavy applications of product after initial spraying resulted in a very wet surface that was only remolded during the traffic test. On the other hand, for samples with longer cure times, a greater number of statistical differences were found at higher application rates. Many of the samples at the lighter application rates had variable performance indicated by partial deterioration of the surfaces. The resistance to wind erosion was moderate, and some samples performed well while identical samples were greatly eroded. For those samples treated with 0.8 gsy, a sufficient thickness was imparted to the sample to resist deterioration from wind. Samples with brittle, weak crusts were affected by the traffic test as indicated by the statistical analysis. In general, the test did identify products that would be affected by traffic, and the data correlate well with previously mentioned field testing.

Effect of application rate on performance

The effect of application rate on product performance was investigated by comparing performance data for each product applied at 0.2, 0.4, and 0.8 gsy. Performance was expected to increase with the increase in application rate; however, the objective of the study was to identify minimum concentrations at which sufficient performance was observed. Figures 14-21**Error! Reference source not found.** depict the data for each testing condition as a function of application rate.

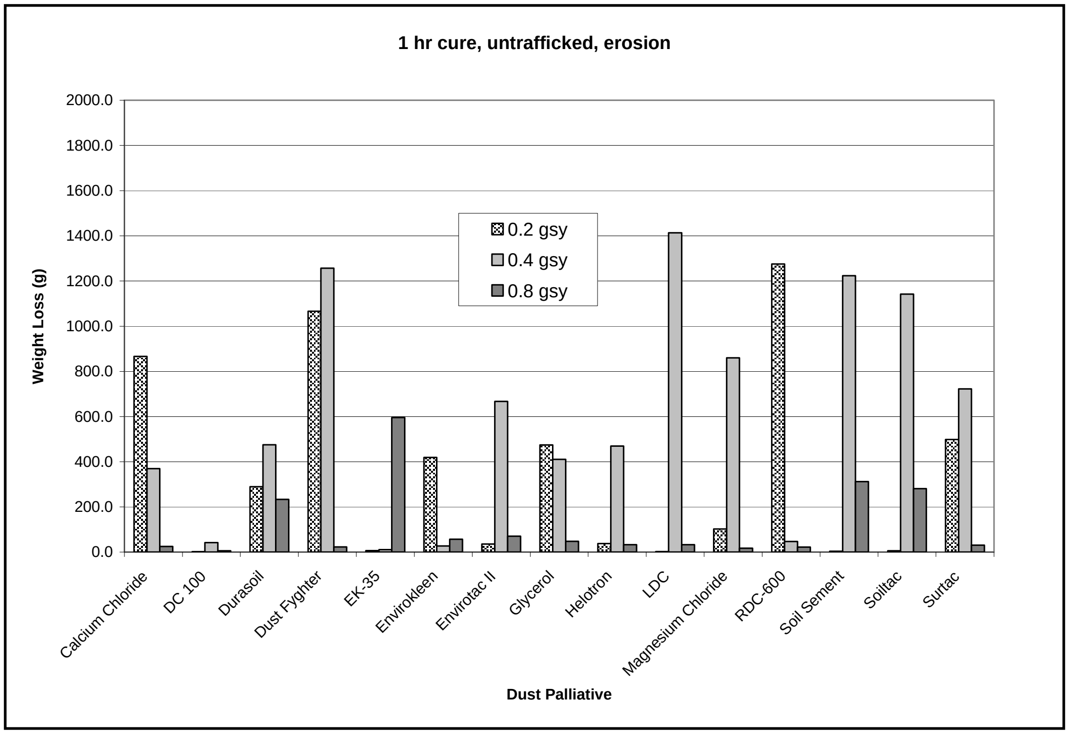


Figure 14. Effect of application rate for 1 hr cure, untrafficked, erosion data.

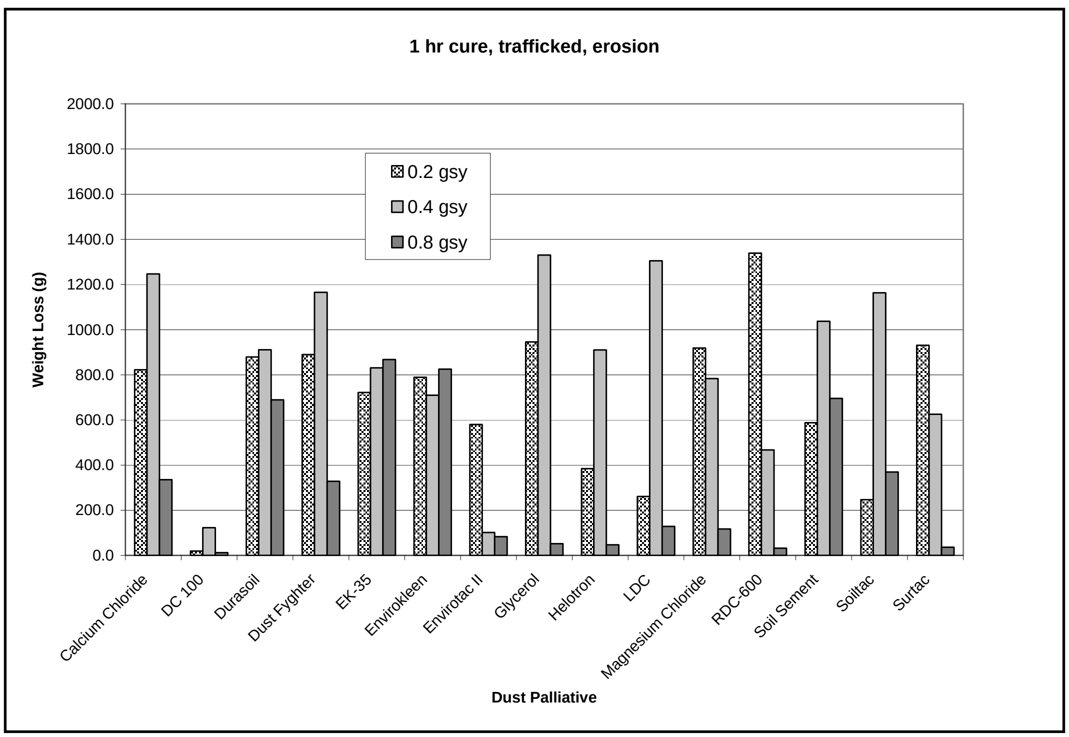


Figure 15. Effect of application rate for 1 hr cure, trafficked, erosion data.

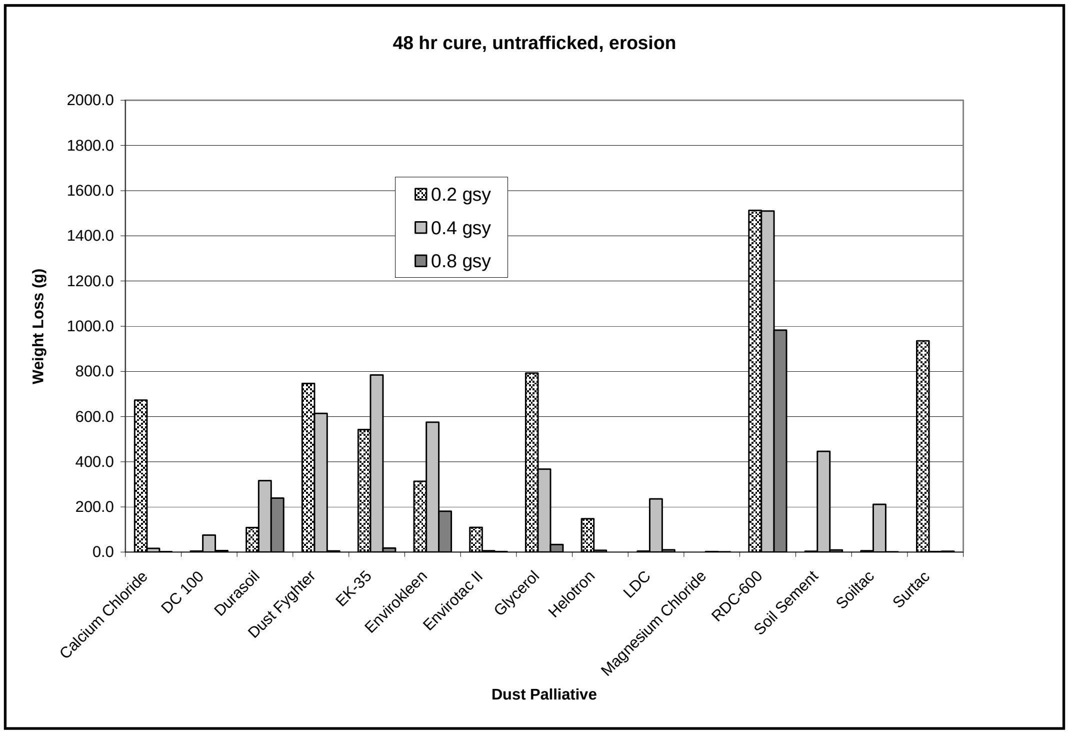


Figure 16. Effect of application rate for 48 hr cure, untrafficked, erosion data.

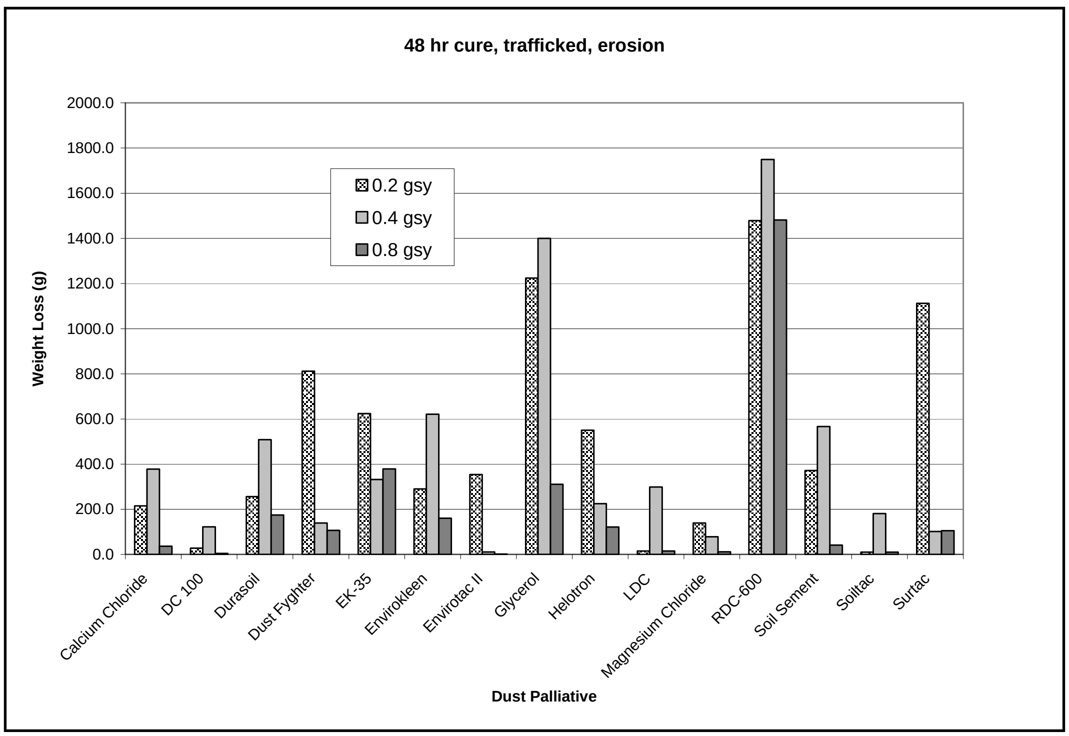


Figure 17. Effect of application rate for 48 hr cure, trafficked, erosion data.

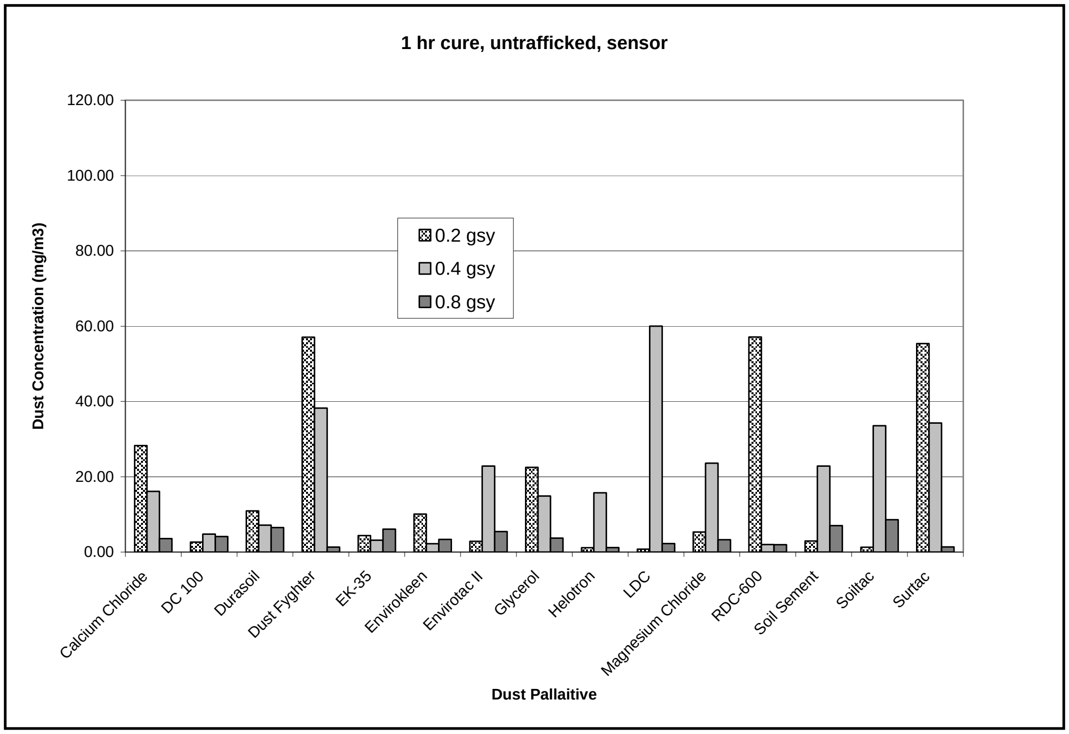


Figure 18. Effect of application rate for 1 hr cure, untrafficked, sensor data.

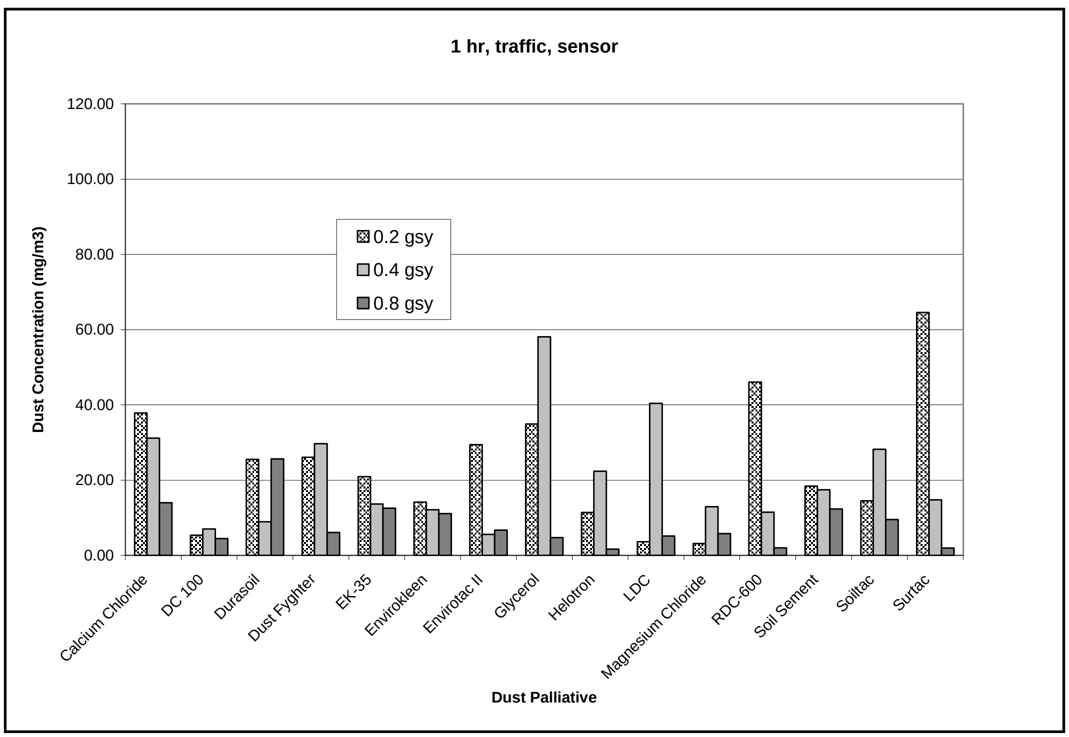


Figure 19. Effect of application rate for 1 hr cure, trafficked, sensor data.

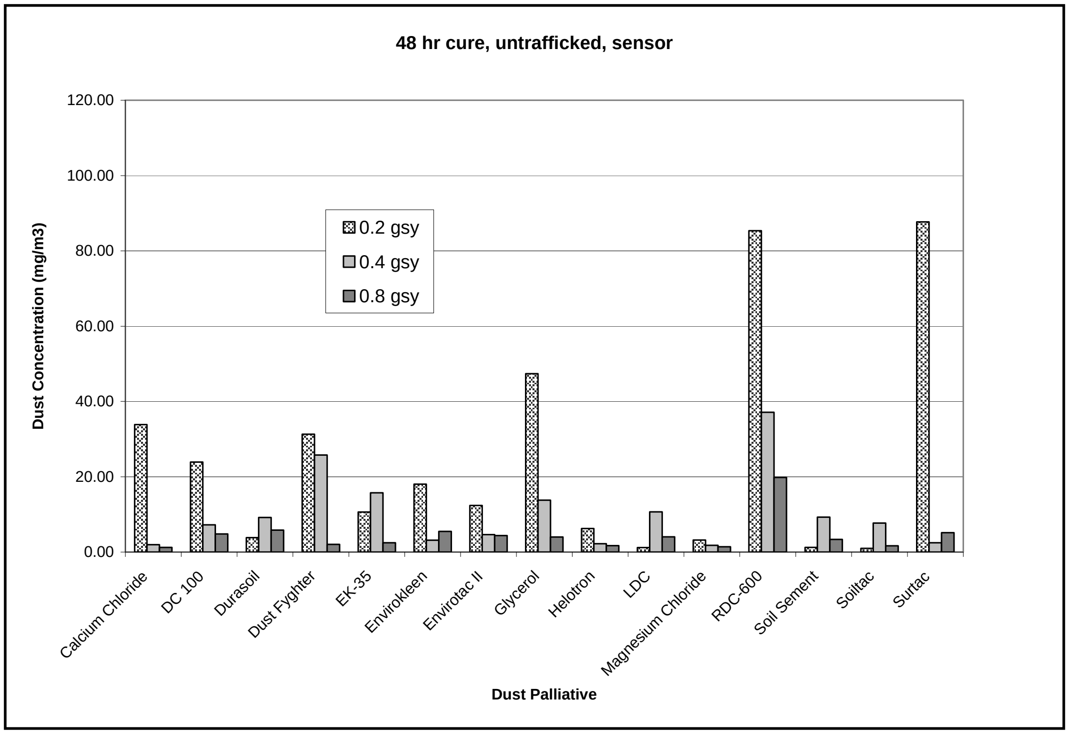


Figure 20. Effect of application rate for 48 hr cure, untrafficked, sensor data.

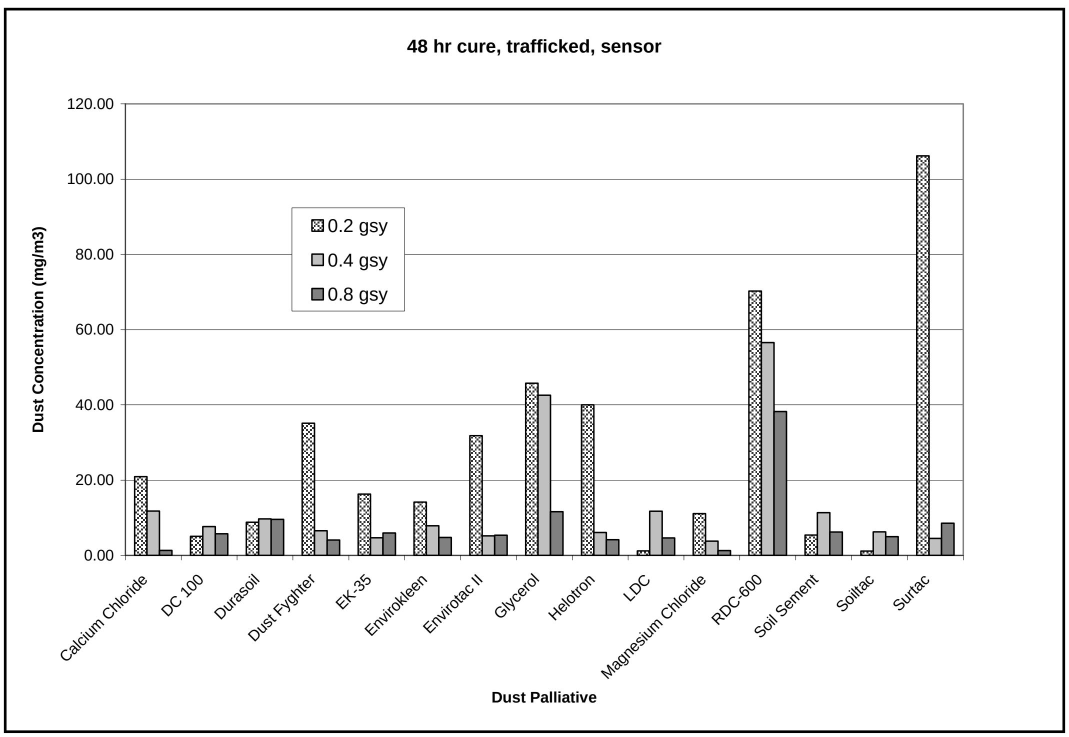


Figure 21. Effect of application rate for 48 hr cure, trafficked, sensor data.

As expected, the data show a general increase in dust palliative effectiveness with increasing treatment quantities. This trend is evidenced in most testing conditions. Additionally, many of the products were ineffective when applied at 0.2 gsy. This application rate is similar to that often recommended by product manufacturers. The data show that it may be necessary to place higher concentrations of product on the soil surface in order to achieve the necessary performance.

Effect of cure time on performance

Samples were cured for different lengths of time in order to determine how long use of the area should be delayed after treatment. Some products were expected to allow immediate use while others were anticipated to require longer periods of time to allow for the inherent curing mechanism to take place before full effectiveness would exist. Data for samples with both 1- and 48-hr cure times were compared to determine the effect of time on performance for each type of dust palliative. The data for each set of treatment conditions were analyzed statistically using a two-sample t-test with the treatment groups consisting of the sets of samples of which the only variation was the time that they were allowed to cure before testing. The confidence limit for the analysis was set at 95 percent for all evaluations. Statistical analysis was performed using SigmaStat® software. Results from the analysis are given in Table 15. The presence of the X in the table indicates that a statistical difference did exist between groups tested after 1 and 48 hr.

Table 15. Statistical differences found between different curing durations.

	Erosion						Sensor					
	Untrafficked			Trafficked			Untrafficked			Trafficked		
	0.2 gsy	0.4 gsy	0.8 gsy	0.2 gsy	0.4 gsy	0.8 gsy	0.2 gsy	0.4 gsy	0.8 gsy	0.2 gsy	0.4 gsy	0.8 gsy
Durasoil				X						X		
Envirokleen							X					
Soil~Sement	X	X			X		X	X				
Soiltac		X		X	X			X		X	X	
Envirotac II			X		X					X		
Liquid Dust Control		X		X	X			X		X	X	
Calcium chloride	X			X	X							
Magnesium chloride				X						X		
Surtac			X		X				X		X	X
Glycerol												
Helotron	X	X	X			X	X	X				X
DC 100	X			X			X			X		
Dust Fyghter				X	X	X				X		
EK-35			X				X					X
RDC 600	X	X	X	X	X	X	X	X	X	X	X	X

The data from the two different curing times were analyzed to determine what effects the curing process had on dust palliative performance. Several of the products are known to undergo physical changes with time. These changes occur mainly from emulsified products coalescing and forming a continuous film. Evaporation of the carrier water is expected to occur and to have an impact on the performance in the laboratory test.

In general, the products that form films or bind soil grains together had statistically different performance values during testing. This trend was observed by both data collection systems. The evaporation of water from the soil surface resulted in a change in the resistance to wind erosion. This was especially true for samples treated with lower application rates. The higher concentrations of dust palliative most likely had good performance in the initial state from the excess water in the soil, and they also performed well after curing because of the high concentration of product and excellent bonding characteristics of the products.

5 Conclusions and Recommendations

The purpose of this study was to devise a testing protocol for rapidly screening potential chemical dust palliatives. The primary performance parameter measured in this study was resistance to wind erosion. The laboratory equipment fabricated for these experiments was designed to replicate the product application and the environmental conditions to which dust palliatives would be subjected. Fifteen commercial and experimental dust palliatives were selected that represent the variety of chemical types currently used in the commercial sector. The following conclusions are given based upon laboratory testing at the ERDC in FY05 and FY06:

a. The application device fabricated for dispersing dust palliatives provided an excellent method for achieving uniform distribution and desired application rates. This design produced flow rates, velocities, and profiles very similar to field applicators.
b. Placing treated samples under infrared lamps provided an efficient mechanism for accelerating water evaporation and subsequent curing of dust palliatives, which was similar to field curing conditions.
c. The air impingement device was capable of imparting consistent air velocities capable of eroding the surface of treated samples. The percentage of the area on the surface of samples that eroded varied from 0 to 100 percent depending on the effectiveness and quantity of product.
d. The traffic simulation device caused the surface of some treated samples to crack. However, the statistical variability within the sample sets obscured the data and presented difficulty in determining the effect of the test.
e. Measuring the weight of material dislodged from the sample during the air impingement test provided quantitative data for comparing dust palliative effectiveness. This method of comparison does not differentiate between soil that is eroded and soil that stays suspended in the air as dust. Some products provide little resistance to wind erosion but agglomerate soil particles so that they do not become airborne. Dual measurement of both soil erosion and airborne particulates is necessary to effectively measure dust properties.
f. The optical sensing device provided quantitative comparisons of the dust palliatives by only measuring particles less than 100 microns. This method of comparison more accurately characterizes product performance, but is limited to certain soil types. High concentrations of detectible particles in the soil would easily exceed the maximum concentration of 200 mg/m^3 for the sensor.

g. Placing samples under the curing lamps resulted in statistically different performance values for many of the products. The change in performance is attributed to the change in physical properties of the palliatives from water evaporation (when applicable). Slight changes in physical properties of the active constituents of some palliatives may result from thermal differences resulting from the infrared radiation.
h. The air impingement test does not simulate the effect of wheeled vehicles on dust-treated soils.
i. Polymer emulsions used as dust palliatives form a hard, tough crust on the soil surface. The crust thickness is governed by the product quantity applied and soil properties. Thin crusts are not able to withstand excess forces from wind or vehicles. Any disturbed areas will reveal untreated soil underneath.
j. The emulsified rubber performed similarly to the polymer emulsions. This product had similar properties but formed a more flexible surface crust. The crust was more difficult to disturb but generally thinner for similar quantities of product.
k. The synthetic fluids did not form a hard crust on the surface of treated samples. They provided marginal resistance to erosion in the air impingement test. The performance was not highly dependent on application rate. The fluids had higher penetration depths during the longer curing time. The penetration for these products was greater than any other type of product.
l. The properties of the chloride salts were dependent on the environmental conditions. Samples cured for 1 hr had a soft, wet surface. Samples cured for 48 hr were very brittle from the loss of water through evaporation.
m. The polysaccharide exhibited properties similar to the chloride salts. Curing resulted in a brittle surface crust.
n. The samples treated with glycerol exhibited properties similar to the synthetic fluids. These samples performed more poorly than the synthetic fluids during the air impingement test.
o. The emulsified hydrocarbon performed poorly in all tests. This product was unable to provide resistance to the air impingement test.

The laboratory testing described in this document provided a methodology for performance-based testing of dust palliatives. Results from these procedures may not fully correlate with field performance. Variations in soil type, climate, soil gradation, and relative density will impact product performance. Small-scale field trials are recommended prior to selecting product types and quantities.

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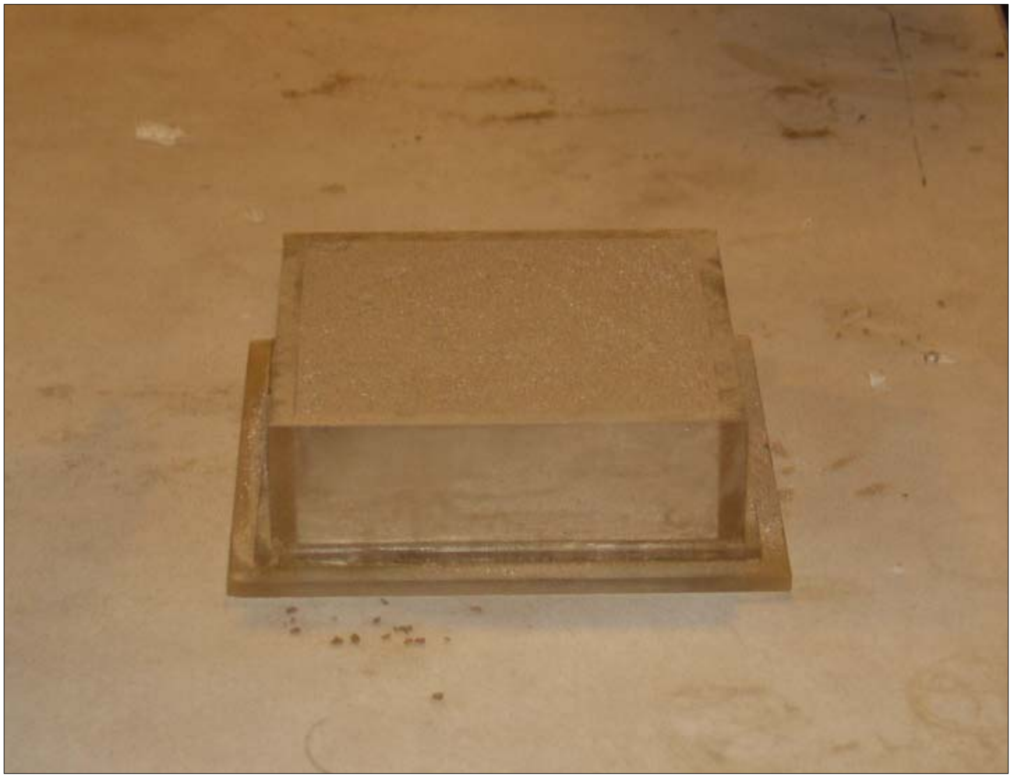

Photo 1. Sample container filled with Yuma sand.

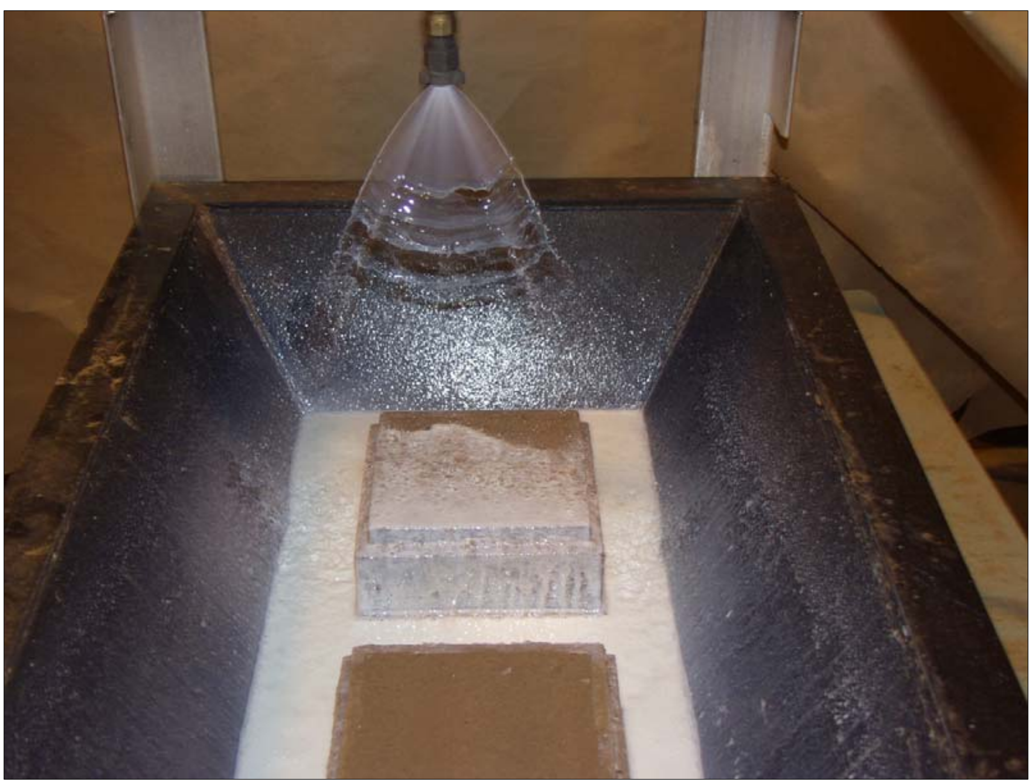

Photo 2. Spray container for product application device.

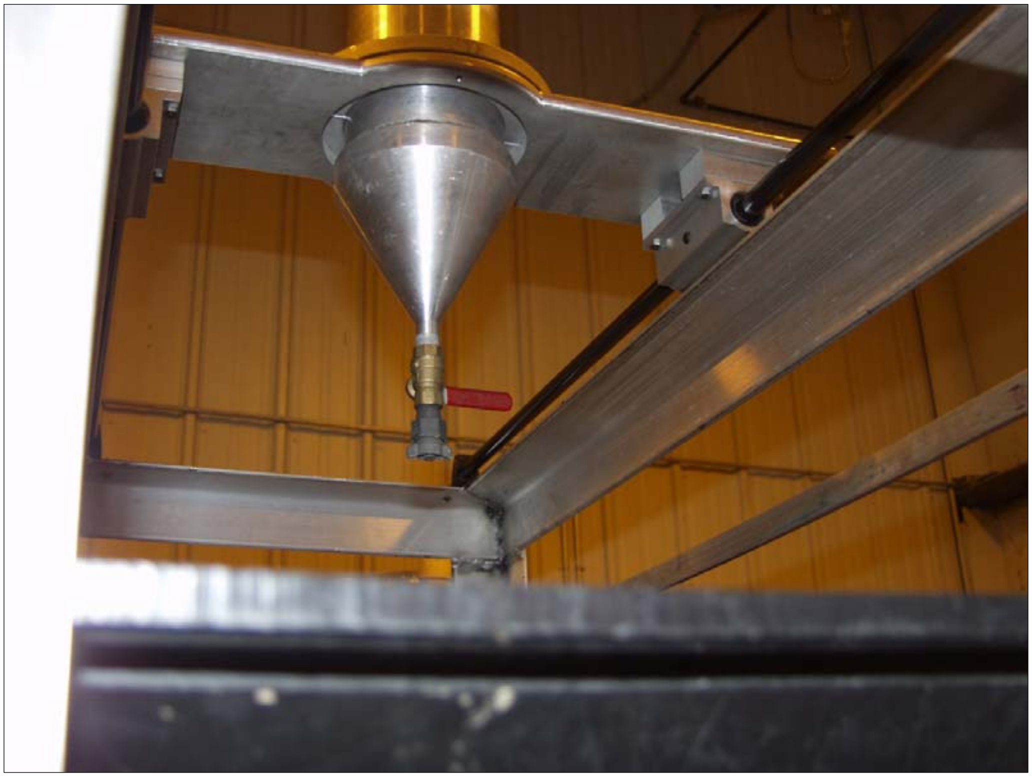

Photo 3. Palliative distribution container.

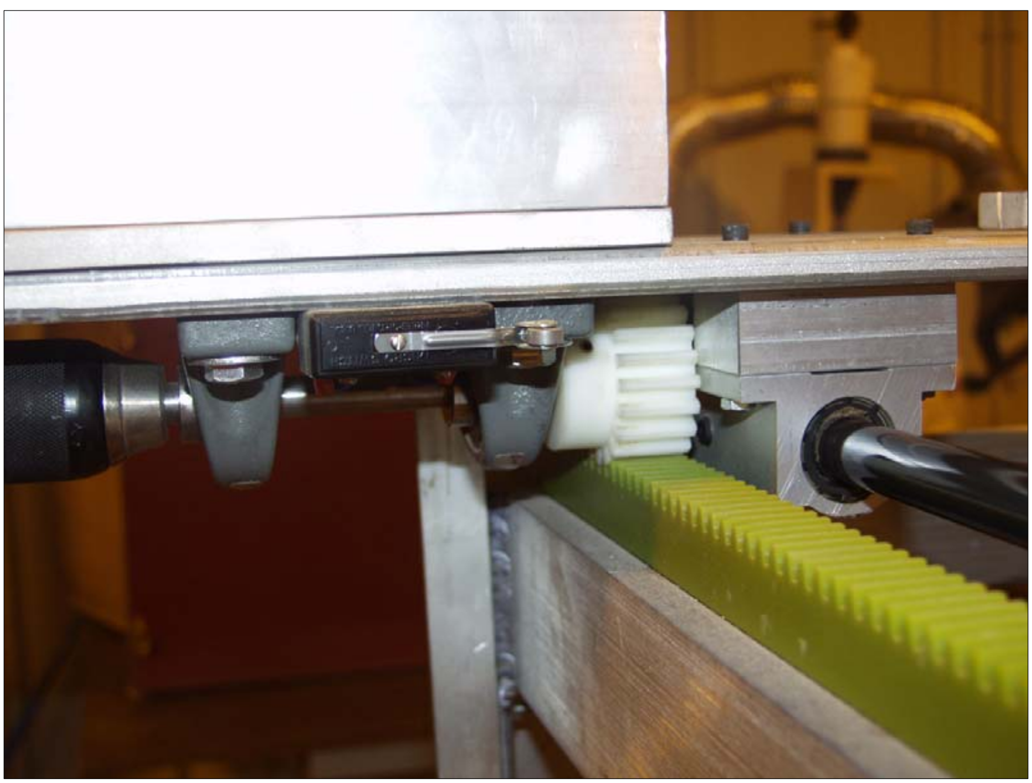

Photo 4. Geared transfer device for controlled product application.

Photo 5. Infrared lamps for curing treated samples.

Photo 6. Testing chamber for air impingement test.

Photo 7. Air discharge aperture inside testing chamber.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*
June 2007

2. REPORT TYPE
Final report

3. DATES COVERED *(From - To)*

4. TITLE AND SUBTITLE
Laboratory Investigation of Chemical Dust Palliative Performance on Sandy Soil

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
John F. Rushing, J. Kent Newman, and Timothy J. McCaffrey

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Engineer Research and Development Center, Geotechnical and Structures Laboratory, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199

8. PERFORMING ORGANIZATION REPORT NUMBER
ERDC/GSL TR-07-19

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Headquarters, U.S. Army Corps of Engineers, Washington, DC 20314-1000;
Marine Corps Systems Command, Quantico, VA 22134-5010

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT
The U.S. Army and Marine Corps initiated a search for chemical dust palliatives for mitigating dust on helipads. The purpose of this investigation was to evaluate the effectiveness of current technologies for suppressing dust caused by rotor wash during helicopter landings. The study used an air impingement device to simulate wind speeds similar to field conditions. Chemical dust suppressants were applied topically to prepared soil specimens and allowed to cure for 1 and 48 hr. Effectiveness was determined from the relative weight loss of the soil samples from erosion during the test procedure. An optical sensor was installed in the test device to provide an additional method for quantifying performance.

15. SUBJECT TERMS
Dust
Dust abatement
Dust control
Dust mitigation
Helipad

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			19b. TELEPHONE NUMBER *(include area code)*
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED		58	